CAMBION®

TEMPERATURE CONTROL BY

THERMOELECTRICS

...for Science and Industry

MODULES • POWER SUPPLIES • ASSEMBLIES • STAGES • CONTROLLERS • BATHS • INDICATORS

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INDEX

*DISCONTINUED

INTRODUCTION

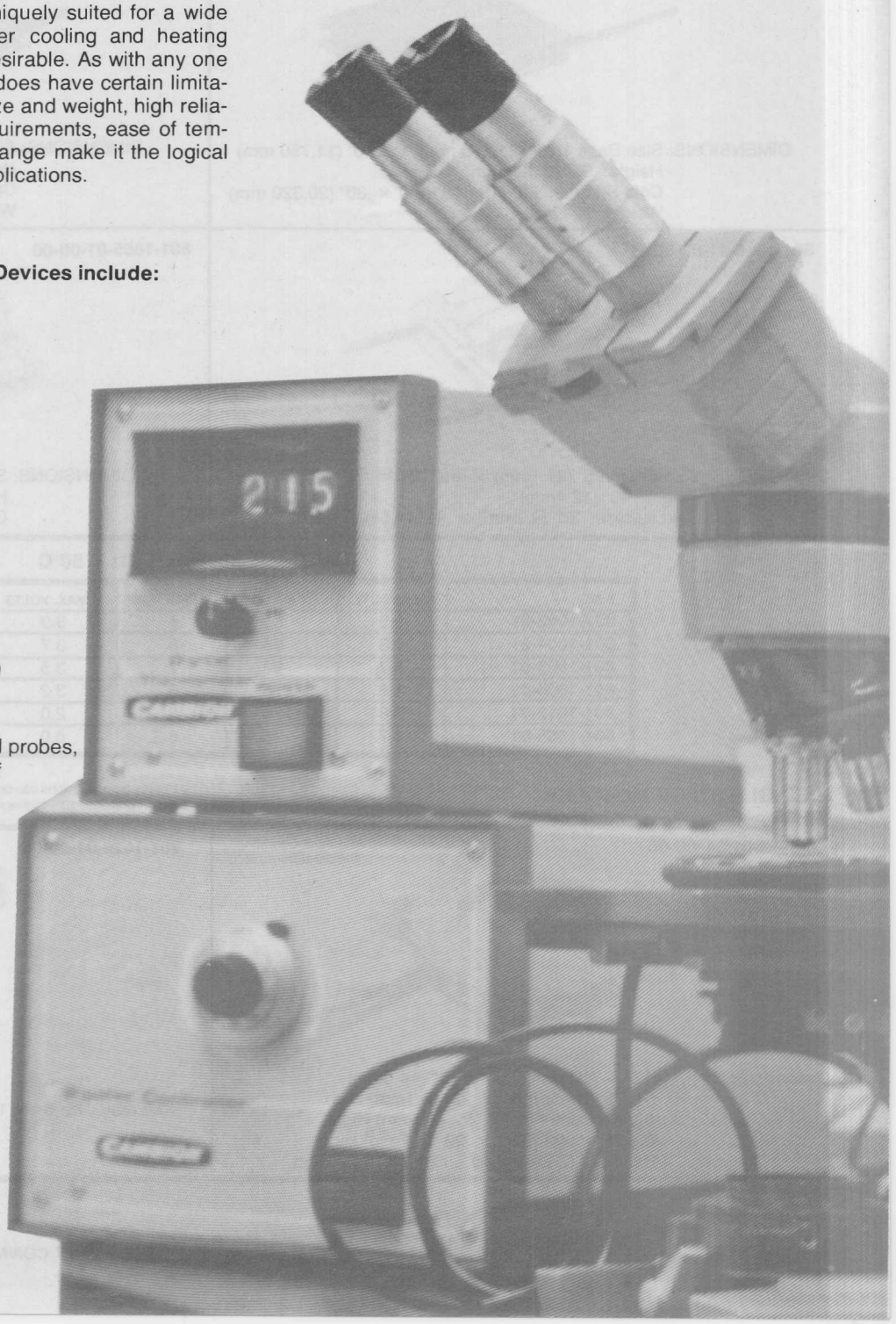
Cambion is the first manufacturer of thermoelectric products to offer a variety of instruments for Science and Industry. We are continually striving to offer new products which can be utilized in many applications. Although Cambion offers the largest line of standard thermoelectric products in the industry, we recognize and value the technological improvements often resulting from special customer requirements. Cambion offers wide engineering experience in handling special customer problems from unusual thermoelectric modules to sophisticated temperature control systems. We appreciate your continued interest in thermoelectrics and welcome your specialized applications.

APPLICATIONS FOR THERMOELECTRIC COOLING

Thermoelectric cooling devices are uniquely suited for a wide range of applications for which other cooling and heating methods are either impractical or undesirable. As with any one given method, thermoelectric cooling does have certain limitations, but advantages such as small size and weight, high reliability, simplicity, convenient power requirements, ease of temperature control, and wide operating range make it the logical and, perhaps, only choice for many applications.

Typical Applications for Thermoelectric Devices include:

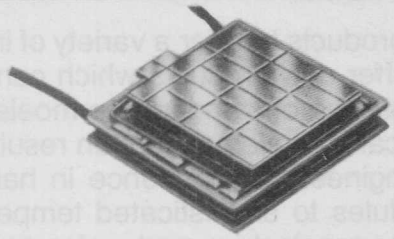
- Cooling of IC chips (CCD's, etc.)
- Vacuum chamber cold traps
- Temperature control of electronic packages and components
- Infrared detection devices and calibration sources
- Photomultiplier and vidicon tube cooling
- Portable refrigerators
- Missile and space applications (inertial guidance systems, etc.)
- Restaurant cooling applications
- Temperature controlled baths, chambers, and cabinets
- Component test fixtures (in laboratory or production environments)
- Dehumidifiers and dewpoint hygrometers
- Medical test equipment (blood analyzers, test tube coolers, microscope stages, cold probes, microtome stages, temperature control of tissues and cultures, etc.)
- Temperature control of lasers and laser trimmers
- Calorimeters
- Freeze scribing
- Cooling of parametric amplifiers
- Air pollution analyzers
- Small water coolers
- Temperature control of Wafer Probing Equipment
- Freezing point apparatus



CAMBRIDGE THERMIONIC CORPORATION
CAMBION®
Standardize on Cambion . . . the guaranteed thermoelectrics

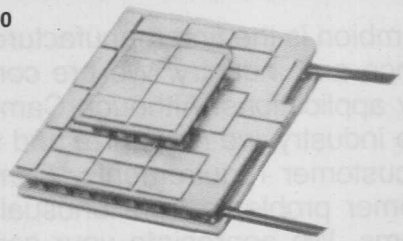
MULTI-STAGE MODULES

801-1003-01-00-00



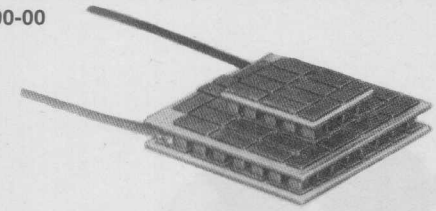
DIMENSIONS: Size Base 1.25″ (31,750 mm) × 1.25″ (31,750 mm)
Height: .35″ (8,890 mm) × Ref.
Cold Surface: 1.10″ (27,940 mm) × .95″ (24,130 mm)
Weight: 31 Grams

801-1004-01-00-00



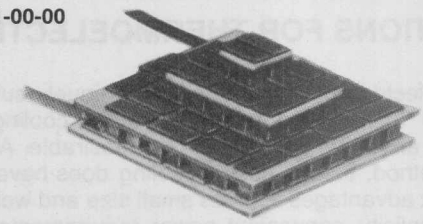
DIMENSIONS: Size Base 1.25″ (31,750 mm) × 1.25″ (31,750 mm)
Height: .35″ (8,890 mm) × Ref.
Cold Surface: .65″ (16,510 mm) × .50″ (12,700 mm)
Weight: 26 Grams

801-1005-01-00-00



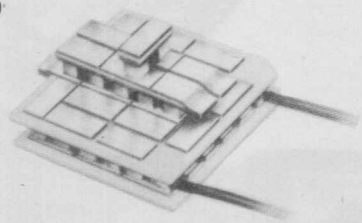
DIMENSIONS: Size Base 1.25″ (31,750 mm) × 1.25″ (31,750 mm)
Height: .35″ (8,890 mm) × Ref.
Cold Surface: .65″ (16,510 mm) × .80″ (20,320 mm)
Weight: 27 Grams

801-1006-01-00-00



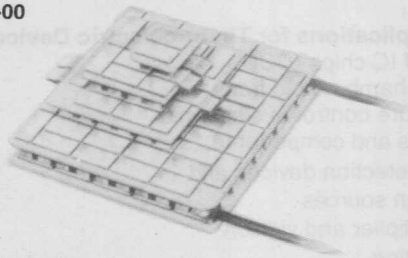
DIMENSIONS: Size Base 1.25″ (31,750 mm) × 1.25″ (31,750 mm)
Height: .49″ (12,446 mm) × Ref.
Cold Surface: .36″ (9,144 mm) × Sq. Ref.
Weight: 29 Grams

801-1016-01-00-00



DIMENSIONS: Size Base .95″ (24.1mm) × .95″ (24.1mm)
Height: .49″ (12.4mm)
Cold surface: .36″ (9.1mm) × .18″ (4.6mm) ref

801-1055-01-00-00



DIMENSIONS: Size Base: 1.50″ (38.1mm) × 1.50″ (38.1mm)
Height: .63″ (16.0mm)
Cold surface: .36″ (9.1mm) × .36″ (9.1mm)

CASCADE MODULE, Th = 50°C

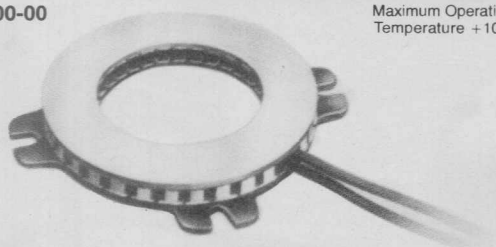
P/N	Qc MAX. W.	ΔT MAX. °C	I MAX. AMP	V MAX. VOLTS	NO. STAGES	Wt. in gms.
801-1003-01	9.0	80	6	3.9	2	31
801-1004-01	4.3	95	8	3.7	2	26
801-1005-01	5.7	90	7	3.5	2	27
801-1006-01	1.6	115	6	3.2	3	29
801-1016-01	0.8	110	8	2.0	3	20
801-1055-01	1.7	125	6.3	6.0	4	40

SINGLE-STAGE MODULES

*The values of Qc obtained from the 801-2001-01 performance graphs can be applied to other modules, by multiplying by the appropriate Qc factor. The graphs show minimum performance. In practice, 10% higher Qc and ΔT can be obtained.

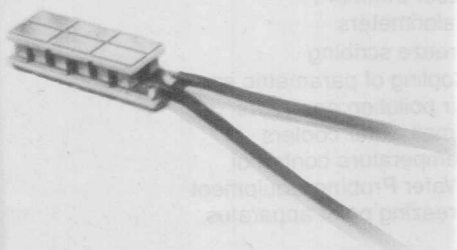
800-3953-01/04 -00-00

Maximum Operating Temperature +100°C



Dimensions: O.D.—All Dash Nos.: 1.75″ (44.5mm)
-01: .75″ (19mm) ID × .28″ (7.1mm) High
-02: No Center Hole: .28″ (7.1mm) High
-03: .25″ (6.4mm) ID × .28″ (7.1mm) High
-04: 1.06″ (26.9mm) ID × .21″ (5.3mm) High

801-1029-01-00-00

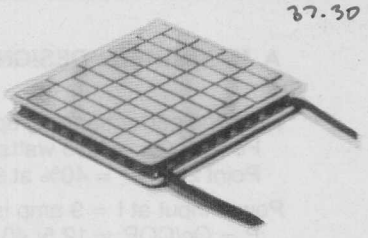


DIMENSIONS: Size: 1″ (25.4mm) × .3″ (7.6mm) × .21″ (5.3mm)

SINGLE STAGE MODULES CONT.

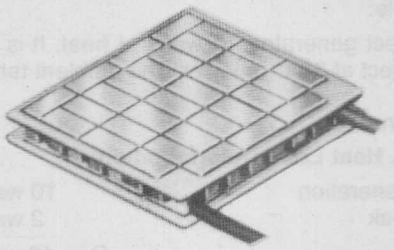
801-2000-(01/02)-00-00
801-2002-(01/02)-00-00
801-1081-01-00-00

HOW TO ORDER CODE
801-2000 Series Modules
801-200X-(XX)-00-00
Thickness Tolerance Table
-01-(XX) = ± .01
-02-(XX) = ± .001



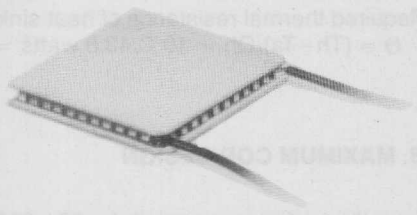
DIMENSIONS: Size 1.50″ (38.1 mm) × 1.50″ (38.1 mm) × 0.21″ (5.334 mm) ± .01 (0,254 mm)
Weight: 28 Grams

801-2001-(01/02)-00-00
801-3958-01-00-00



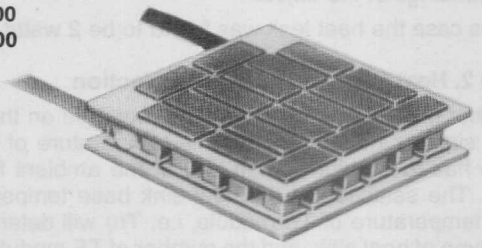
DIMENSIONS: Size 1.25″ (31,750 mm) × 1.25″ (31,750 mm) × 0.21″ (5,334 mm) ± .01″ (0,254 mm)
Weight: 23 Grams

801-2003-01-00-00



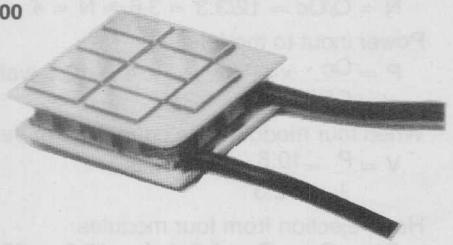
DIMENSIONS: Size: 1.25″ (31.8mm) × 1.25″ (31.8mm) × .15″ (3.8mm)

801-3959-01-00-00
801-3965-01-00-00



DIMENSIONS: Size .95″ (24,130 mm) × .95″ (24,130 mm) × 0.210″ (5,334 mm) + .000″ − .005″ (0,127 mm)
Weight: 15 Grams

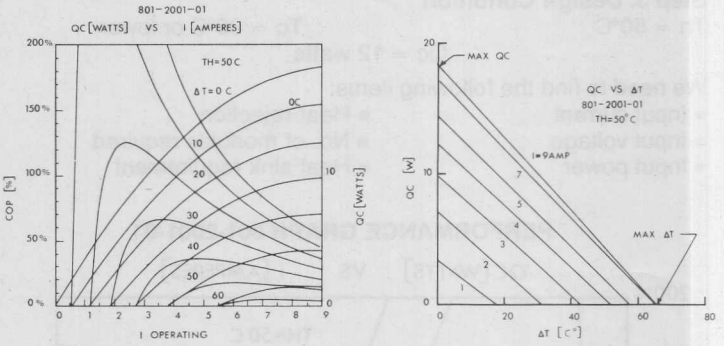
801-3960-01-00-00



DIMENSIONS: Size .65″ (16,510 mm) × .80 (20,320 mm) × 0.210″ (5,334 mm) + .000″ − .005″ (0,127 mm)
Weight: 10 Grams

Maximum Module Operating Temperature 150°C

PERFORMANCE GRAPHS OF 801-2001-01-00-00



See Next Page and Page 26 for Instructions

SINGLE STAGE MODULE, Th = 50°C

*The values of Qc obtained from the 801-2001-01 performance graphs and tables on page 28 to 30, can be applied to other modules, by multiplying by the appropriate Qc factor. The graphs show minimum performance. In practice, 10% higher Qc and ΔT can be obtained.

P/N	Qc MAX. W.	ΔT MAX. °C	I MAX. AMP.	V MAX. VOLTS	Qc* Factor	Wt. in gms.	Number of Couples
800-3953-01/04	12.0	50	7	4.0	.70	28	31
801-1029-01	3.3	60	9	0.7	.193	5	6
801-1081-01	45.0	60	14	6.0	2.46	30	49
801-2000-01	29.0	60	9	6.0	1.58	28	49
801-2001-01	19.0	60	9	3.5	1.00	23	31
801-2002-01	22.0	60	7	6.0	1.23	28	49
801-2003-01	26.0	60	6	10.0	1.96	20	71
801-3958-01	20.0	65	9	4.0	1.05	23	31
801-3959-01	9.0	60	9	2.0	.55	15	17
801-3960-01	4.0	60	9	1.0	.29	10	9
801-3965-01	7.0	60	7	2.0	.43	15	17

Example:

An object generates 10 watts of heat. It is desired to maintain this object at 30°C or lower. The ambient temperature is 40°C.

Solution:

Step 1. Heat Load Determination

Heat generation	10 watts
Heat leak	2 watts
	Q = 12 watts

The heat leak to the object from ambient has to be considered. The amount of heat leak is decided by temperature, size and surroundings of the object.

In this case the heat leak was found to be 2 watts.

Step 2. Heat Sink Temperature Selection

The hot side of the TE module is mounted on the base of the heat sink for heat rejection. The temperature of the heat sink base has to be higher than that of the ambient for transfer of heat. The selection of the heat sink base temperature (or hot side temperature of TE module, i.e. Th) will determine the size and type of heat sink, and the number of TE modules required to handle the heat load.

When a lower Th is selected, a lesser number of modules and input power are required. On the other hand, a larger and more effective heat sink has to be selected.

(CAMBION's application staff is ready to assist you in designing an optimum system.) In this case, the heat sink base temperature is assumed to be 10°C above ambient, i.e. Th = 50°C

Step 3. Design Condition

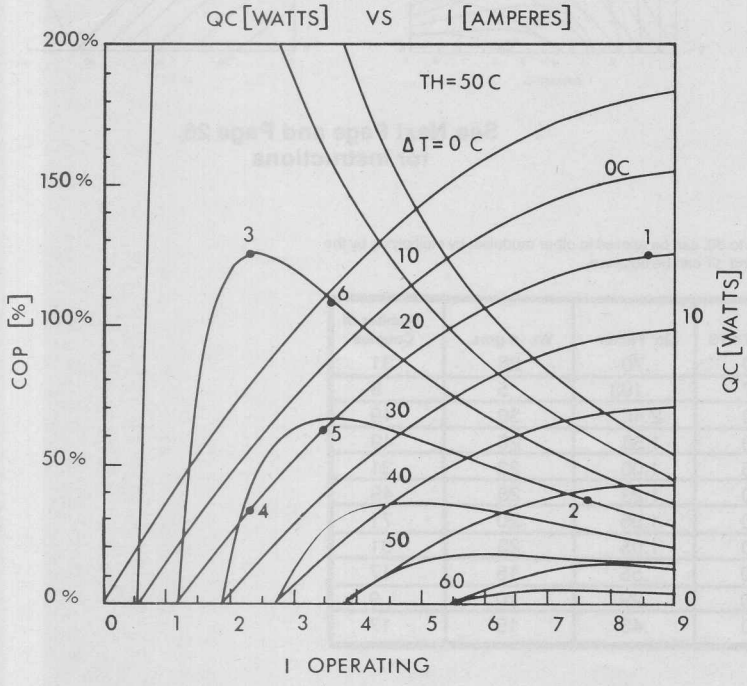
Th = 50°C Tc = 30°C or lower

Qc = 12 watts

We need to find the following items:

- Input current
- Input voltage
- Input power
- Heat rejection
- No. of modules required
- Heat sink requirement

PERFORMANCE GRAPH 801-2001-01



A. MAXIMUM Qc DESIGN

From the performance graph for 801-2001-01
Point 1: Qc = 12.5 watts at 9 amp with one module
Point 2: COP = 40% at 9 amp

Power Input at I = 9 amp is:
$P = Qc/COP = 12.5/.40 = 31.3$ watts

Input voltage is found as:
$V = P/I = 31.3/9 = 3.47$ volts

Heat rejection from one module:
$Qh = Qc + P = 12.5 + 31.3 = 43.8$ watts

Required thermal resistance of heat sink is:
$\Theta = (Th - Ta)/Qh = 10°C/43.8 \text{ watts} = .22°C/W$

B. MAXIMUM COP DESIGN

From the performance graph for 801-2001-01
Point 3: COP = 125% at 2.3 amp
Point 4: Qc = 3.3 watts at 2.3 amp

Number of modules required:
$N = Q/Qc = 12/3.3 = 3.6 \Rightarrow N = 4$

Power input to module:
$$P = \frac{Qc}{COP} \times N = \frac{3.3}{1.25} \times 4 = 10.6 \text{ watts}$$

When four modules are connected in series:
$$V = \frac{P}{I} = \frac{10.6}{2.3} = 4.6 \text{ volts}$$

Heat rejection from four modules:
$Qh = Qc + P = 3.3 \times 4 + 10.6 = 23.8$ watts

Required thermal resistance of heat sink is:
$$\Theta = \frac{Th - Ta}{Qh} = \frac{10°C}{23.8w} = .42°C/W$$

C. PRACTICAL DESIGN

From the performance graph for 801-2001-01
Point 5: Qc = 6.5 watts at 3.4 amp
Point 6: COP = 105% at 3.4 amp

Number of modules required:
$N = Q/Qc = 12/6.5 = 1.85 \Rightarrow N = 2$

Power input to the module:
$$P = \frac{Qc}{COP} \times N = \frac{6.5}{105} \times 2 = 12.4 \text{ watts}$$

When four modules are connected in series:
$$V = \frac{P}{I} = \frac{12.4}{3.4} = 3.6 \text{ volts}$$

Heat rejection from four modules:
$Qh = Qc + P = 6.5 \times 2 + 12.4 = 25.4$ watts

Required thermal resistance of heat sink is:
$$= \frac{Th - Ta}{Qh} = \frac{10°C}{25.4w} = .4°C/W$$

COMPARISON BETWEEN USING MAXIMUM Qc DESIGN, MAXIMUM COP DESIGN AND PRACTICAL DESIGN

	Max. Qc Design (A)	Max. COP Design (B)	Practical Design (C)
Heat Load	12 watts	12 watts	12 watts
Qc with margin	12.5 watts	13.2 watts	13 watts
No. of modules Required	1	4	2
Power Input	31.25 watts	10.56 watts	12.4 watts
Current Input	9 amp	2.3 amp	3.4 amp
Voltage Input	3.5 VDC	4.6 VDC	3.6 VDC
Heat Sink Requirement (Thermal Resistance)	.22°C/w	.42°C/w	.4°C/w

(NOMENCLATURE)

Tc = cold side temperature of thermoelectric module in °C
Th = hot side temperature of thermoelectric module in °C
Ta = ambient temperature in °C
ΔT = temperature difference between hot and cold sides of thermoelectric module in °C
Qc = cooling capacity of thermoelectric module in watts
Qh = heat flow from the hot side of thermoelectric module, generally rejection in watts
θ = thermal resistance of heat sink (°C/Watt)
N = number of thermoelectric modules
P = input power in watts
I = input current in amperes
V = input voltage in volts
COP = coefficient of performance of refrigeration (% efficiency)

POWER SUPPLIES

PART NO. 802-3970-01-00-00

CAMBION Part No. 802-3970-01 is a small variable laboratory power supply designed to be used with a wide variety of CAMBION thermoelectric products. This P/N is useful where manual temperature control of systems is required. Simple in operation P/N 802-3970-01 features both a positive and negative output for either cooling or heating a thermoelectric device.

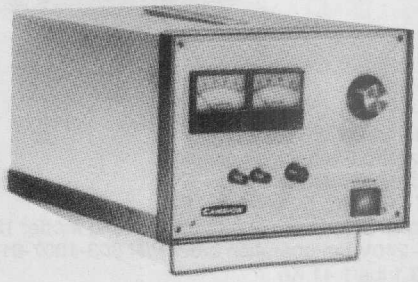
SPECIFICATIONS

Power Output:	0 to 10 Volts DC, 8 amperes maximum
Power Input:	115 ac volts ± 10% at 1.5 amperes 50-60 hertz
Front panel controls:	ON/OFF switch, power output control, polarity reversal switch
Ambient temperature:	−10°C to +35°C (15°F to 95°F)
Height:	6¼" (15.9cm)
Width:	5¼" (13.3cm)
Length:	10¼" (26.0cm)
Weight:	15 lbs. (6.8kg)

PART NO. 802-7230-01-00-00

VARIABLE POWER SUPPLY

The P/N 802-7230-01-00-00 is a controlled-output direct current variable power supply designed to meet the low voltage power requirements of various thermoelectric devices. Built-in panel meters permit continuous monitoring of both output voltage and current.



SPECIFICATIONS

Power Output:	0 to 45 volts DC, 9 amperes maximum
Power Input:	115/230 volts AC ± 10%, 50−60 Hz, 565 watts maximum
Ambient temperature:	−10°C to +45°C (15°F to 115°F)
Height:	8,3" (21cm)
Width:	11,1" (28cm)
Depth:	15,0" (38cm)
Weight:	36 lbs (16 Kg)

POWER SUPPLIES

FIXED-OUTPUT POWER SUPPLIES

Part No's. 802-3971-01-00-00
802-3972-01-00-00
802-3973-01-00-00

The CAMBION 802-3971/3972/3973 series are solid-state, fixed output, nonregulated power supplies designed to be used in conjunction with various thermoelectric devices. These units are useful for applications where temperature control is not required and a relatively economical power supply is desired. By plugging the power supply into a variable auto-transformer ("VARIAC", "POWERSTAT", etc.), it is possible to adjust the DC output voltage from zero to maximum.

SPECIFICATIONS

Part number:	**802-3971-01**	**802-3972-01**	**802-3973-01**
DC Output voltage At rated current:	9V, 8 AMPS 10V, 6 AMPS	3.5V, 8 AMPS 4.0V, 6 AMPS	2.5V, 8 AMPS 3.0V, 6 AMPS
AC Input voltage:	115 VAC 50/60 Hz		
Physical dimensions:			
Height	**4.8" (12,1cm)**	**4.8" (12,1cm)**	**4.8" (13,3cm)**
Width	**6.3" (15,9cm)**	**6.3" (15,9cm)**	**6.3" (15,9cm)**
Depth	**4.8" (12,1cm)**	**4.8" (12,1cm)**	**4.8" (12,1cm)**
Maximum operating Ambient temperature:	35°C (95°F)		
Compatible with thermoelectric devices:	(2) 801-2000-01 (3) 801-2001-01 (2) 801-2002-01 **802-3970-01** 806-7243-01	801-1003-01 801-1004-01 801-1005-01 801-2001-01 801-3958-01 806-1000-01	801-1006-01 (4) 801-1029-01

THERMOELECTRIC ASSEMBLIES

Standard CAMBION Thermoelectric Assemblies (heat pumps) are available with either forced convection or fluid cooled heat sinks which afford the design engineer or scientist wide flexibility in application.

Assemblies are rated in terms of heat pumping capacity which is the maximum number of watts or BTU's (1 watt = 3.41 BTU/hr) which can be removed from a "load" attached to the surface of the assembly when the load and ambient temperatures are equal, i.e. $\Delta T = 0$.

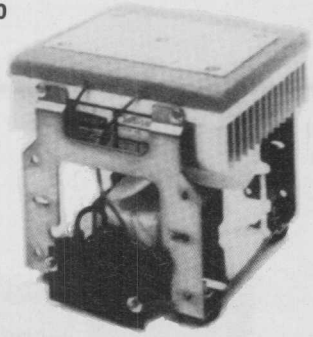
FORCED CONVECTION ASSEMBLIES

CAMBION Forced Convection Assemblies consist of a finned heat sink and cold plate between which are sandwiched two or more thermoelectric modules. A built-in fan provides the required heat sink air flow to facilitate waste heat removal. Because of fan motor limitations, the operating ambient temperature should not exceed +65°C.

A summary of specifications of standard CAMBION Forced Convection thermoelectric assemblies is given in the table to the right. Data shown is referenced to an ambient air temperature of 25°C.

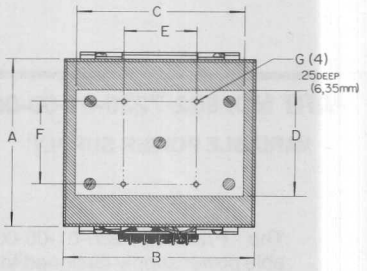
PART NO.	MAX. Qc, WATTS At Tc = 25°C	Cold Plate Temp. Tc At Qc = 0	INPUT MAX. I, AMP	INPUT MAX. V, VOLTS
803-1004-01-00-00	86	−17	6	24
803-1010-01-00-00	26	−20	8	8
803-1011-01-00-00	44	−17	8	16
803-1021-01-00-00	30	−45	6	24

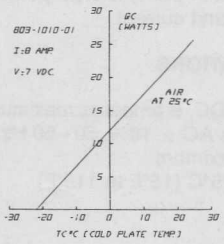
Part No.: 803-1010-01-00-00

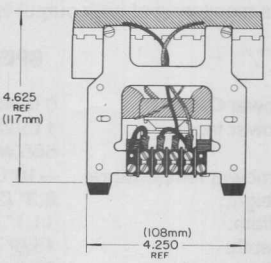


Max. Qc at Tc = 25°C: 26 watts
Cold Plate temp at Qc = 0: −22°C
DC input current: 8 amperes optimum
DC input voltage: 8 volts nominal
Fan power: 115 VAC, 50−60 Hz, 16W
—Maximum cold plate temperature in heating mode: 125°C
—For 220−240V fan operation order P/N 803-1007-01-00-00
—Weight: 3.1 lbs/1.41 Kg

	(Inch)	(mm)
A.	4.37	111
B.	5.00	127
C.	4.31	109
D.	2.75	70
E.	1.87	47,5
F.	2.25	57,2

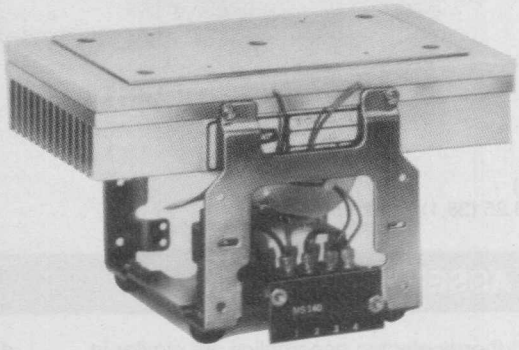


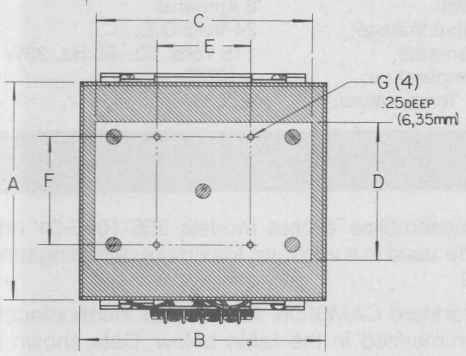


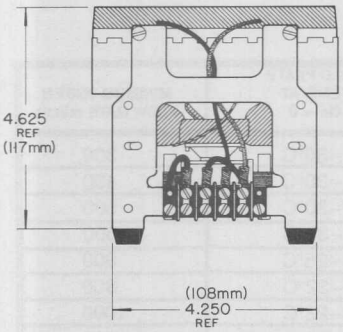


CAMBION® ... THE RIGHT CONNECTION

Part No.: 803-1011-01-00-00

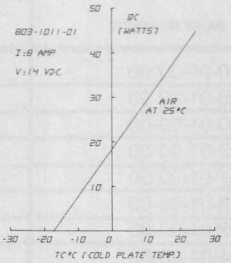




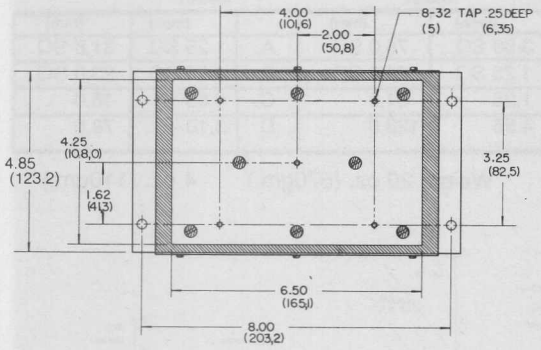


803-1011-01	(Inch)	(mm)
A	4.37	111
B	8.00	202
C	6.50	165
D	3.75	95
E	3.50	89
F	2.75	70

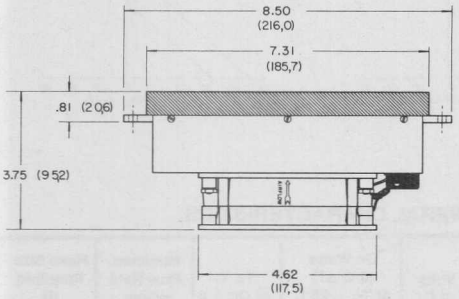
Max. Qc at Tc = 25°C: 44 watts
Cold Plate temp at Qc = 0: −17°C
DC input current: 8 amperes optimum
DC input voltage: 16 volts nominal
Fan power: 115 VAC, 50−60 Hz, 16W
— Maximum cold plate temperature in heating mode: 125°C
— For 220−240V fan operation order P/N 803-1008-01-00-00
— Weight: 4.5 lbs/2.05 Kg



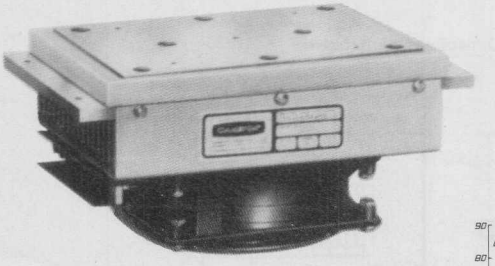
Part No.: 803-1004-01-00-00

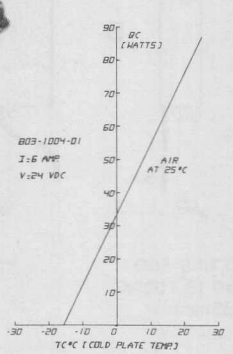


ALL DIMENSIONS ARE REFERENCE



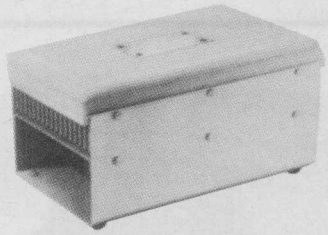
Max. Qc at Tc = 25°C: 86 watts
Cold Plate temp at Qc = 0: −17°C
DC input current: 6 amperes optimum
DC input voltage: 24 volts nominal
Fan power: 115 VAC, 50−60 Hz, 23W
— Maximum cold plate temperature in heating mode: 125°C
— For 220−240V fan operation order P/N 803-1009-01-00-00
— Weight: 4.75 lbs/2.16 Kg





CASCADE FORCED CONVECTION ASSEMBLY

Part No. 803-1021-01



Dimensions:

Length: 10″ (254,0)
Width: 5.37″ (145,54)
Height: 5.5″ (139,7)
Weight: 6.75 lbs (171,45)
Hot cold surface: 1.5 × 3.25 (38,1) × (82,55)

The CAMBION P/N 803-1021-01 is a two-stage forced convection assembly utilizing thermoelectric components which are "sandwiched" in a pyramid configuration between an aluminum cold plate and heat sink.

SPECIFICATIONS

Heat Pumping Capacity at Zero ΔT:	30 Watts (Ta = 25°C)
Cold Plate Temp. at Zero Heat Load:	−45°C Nominal (Ta = 25°C)
Module Input Current:	6 Amperes
Nominal Module Input Voltage:	24 Volts D.C.
Fan Power Requirements:	115 Volts, 50−60 Hz, 23W
Maximum Plate Temperature:	+125°C
Maximum Ambient Temperature:	+70°C

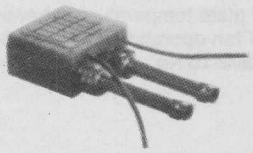
FLUID COOLED ASSEMBLIES

CAMBION's fluid cooled thermoelectric assemblies are similar in operation to forced convection units but utilize a liquid cooled heat sink in place of a fan and finned heat exchanger. This difference results in a unit of smaller size and having improved low-temperature performance as compared with a similarly rated forced convection assembly. Ordinary "tap" water or other non-corrosive liquids may be used to cool the fluid heat sink. All standard fluid cooled assemblies except models 806-1006-01 and 806-7240-01 may be used in a vacuum. Maximum operating temperature is +125°C.

Specifications of standard CAMBION fluid cooled thermoelectric assemblies are summarized in the table below. Data shown is referenced to a cooling fluid temperature of 25°C.

PART NUMBER	MAX. Qc Tc = 25°C	OPTIMUM DC INPUT CURRENT (AMPERES)	NOMINAL INPUT VOLTAGE (VOLTS)	COLD PLATE TEMP. AT Qc = 0	MINIMUM WATER FLOW RATE ml/min
806-7240-01-00-00	6	6.5	2	−30°C	300
806-1006-01-00-00	8.5	9	2	−30°C	400
806-1000-01-00-00	15	9	3.5	−30°C	500
806-7242-01-00-00	15	6.5	5	−30°C	500
806-1001-01-00-00	29	9	7	−25°C	800
806-7243-01-00-00	29	6.5	10	−22°C	800
806-1002-01-00-00	53	9	14	−22°C	1000
806-7244-01-00-00	53	6.5	20	−22°C	1000
806-1003-01-00-00	106	7	26	−15°C	1500

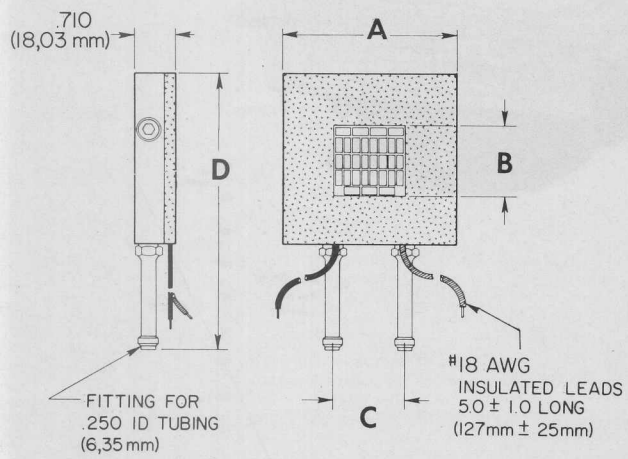
PART NO. 806-1000-01-00-00
806-1006-01-00-00

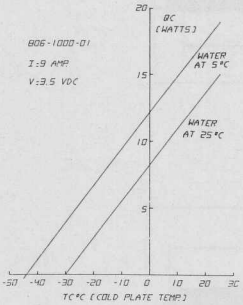


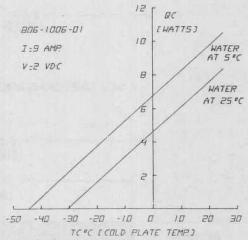
	1000-01 (inch)	1000-01 (mm)		1006-01 (inch)	1006-01 (mm)
A.	3.00 SQ.	76,0 SQ.	A.	1.25 SQ.	31,8 SQ.
B.	1.25 SQ.	31,8 SQ.	B.	0.95 SQ.	23,0 SQ.
C.	1.25	31,8	C.	0.63	16,0
D.	4.85	123,0	D.	3.10	78,6

Weight 20 oz. (570gm.) 4 oz. (110gm.)

All Dimensions are Reference.



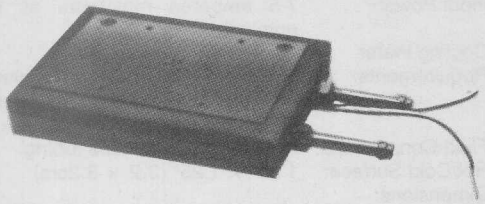




GENERAL CHARACTERISTICS

Part No.	Amps DC Max.	Volts D.C.	Qc Watts (0°C ΔT) at Tc = 25°C	Tc °C at Qc = 0	Minimum Flow Rate ml/min.	Hose Size Required ID
806-1000-01	9	35	15	-30	500	¼″
806-1006-01	9	2	8.5	-30	400	¼″

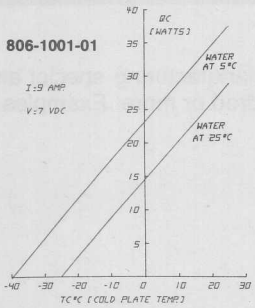
PART NO. 806-1001-01-00-00
806-1002-01-00-00

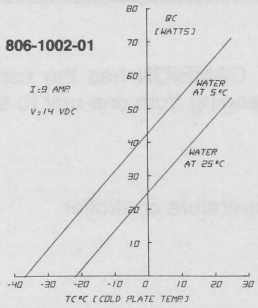


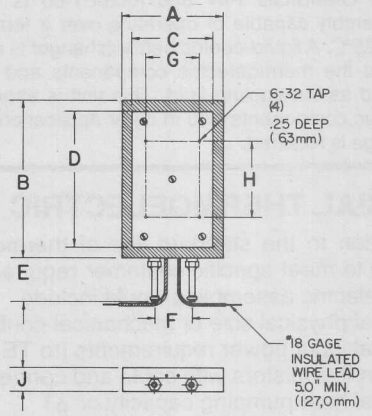
	806-1001		806-1002	
	(inch)	(mm)	(inch)	(mm)
A.	3.50	89,0	4.75	120,0
B.	5.00	127,0	7.50	190,0
C.	2.75	70,0	3.81	97,0
D.	4.31	109,0	6.50	165,0
E.	1.75	44,5	1.75	44,5
F.	1.50	38,2	1.75	44,5
G.	2.25	57,0	2.75	70,0
H.	1.87	47,5	3.50	89,0
J.	0.96	24,4	0.96	24,4
WEIGHT	**2.8 LBS. (1,25Kg)**		**7.3 LBS. (3,3Kg)**	

GENERAL CHARACTERISTICS

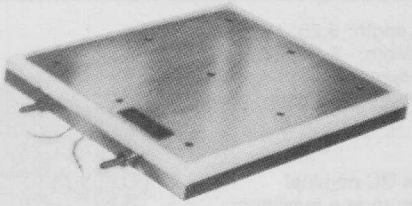
Part No.	Amps DC Max.	Volts D.C.	Qc (0°CΔT) at Tc = 25°C	Tc °C at Qc =0	Minimum Flow Rate ml/min.	Hose Size Required ID
806-1001-01	9	7	29	−25	800	¼"
806-1002-01	9	14	53	−22	1000	¼"



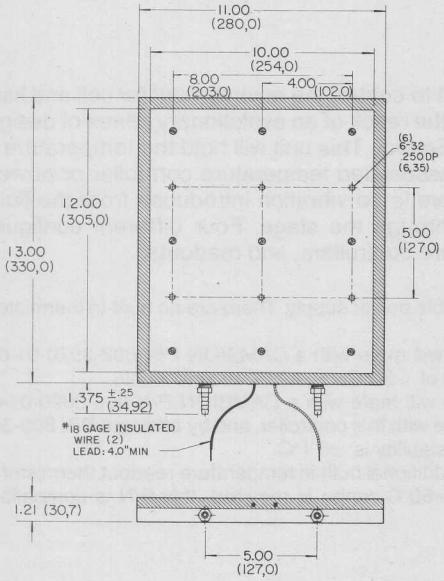


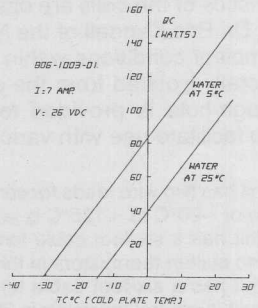


PART NO. 806-1003-01-00-00



Maximum QC at ΔT = 0: 106 Watts
Optimum Input Current: 7 Amperes
Nominal Input Voltage: 26 Volts D.C.
Cold Plate Temp. at Qc = 0: −15°C
Water Flow Rate: 1500 ml/min. minimum
Hose Size Required: ¼" I.D.
Weight: 12.7 LB. (5,8 Kg)

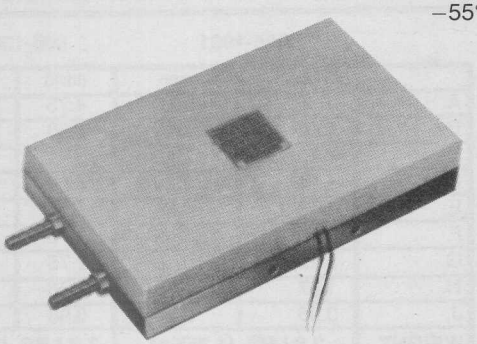




FLUID COOLED ASSEMBLIES

PART NO. 806-1008-01-00-00

SINGLE COMPONENT TEST STATION
−55°C to +125°C



The CAMBION P/N 806-1008-01-00 is a two-stage thermoelectric assembly capable of operating over a temperature range of −55°C to +125°C. A liquid-cooled heat exchanger is utilized to remove waste heat from the thermoelectric components and ordinary tap water may be used as the cooling fluid. This unit is especially useful in testing electronic components and in other applications where a wide temperature range is required.

SPECIFICATIONS

Input Power:	7.5 amperes maximum at 18 volts DC nominal
Cooling Water Requirements:	1000 milliliters per minute minimum at a maximum water temperature of approximately 20°C
Fluid Connections:	Accept ¼″ I.D. flexible tubing
Hot/Cold Surface:	1.25″ × 1.25″ (3.2 × 3.2cm)
Dimensions:	
Length:	7.5″ (19.1cm) plus 1.8″ (4.6cm) extension for fluid fittings
Width:	4.75″ (12.1cm)
Height:	1.38″ (3.5cm)
Weight:	7.8 lbs (3.5Kg)

SPECIAL THERMOELECTRIC ASSEMBLIES

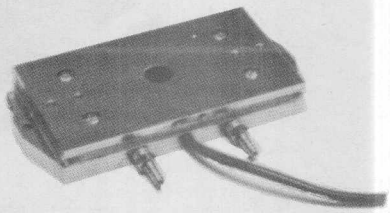
In addition to the standard line of thermoelectric assemblies, CAMBION has the capability of manufacturing special and custom devices to meet specific customer requirements in quantities ranging from one unit to several hundred or more. Examples of special thermoelectric assemblies would include:

- Special physical size or mechanical configuration
- Special input power requirements (to TE modules and/or fan)
- Built-in thermistors with cable and connector to mate with temperature controller
- Special heat pumping capacity or ΔT
- Cascade configurations for lower temperatures
- Special plating
- Special fan or blower for forced convection assemblies
- Air-to-air or air-to-liquid heat exchangers

FLUID COOLED MICROSCOPE STAGES

PART NO'S. 806-1036-01-00-00
806-1036-02-00-00
806-1036-03-00-00
806-1036-04-00-00

DIMENSIONS: Length: 5.25″ (13,3cm)
Width: 2.5″ (5,7cm)
Height: .75″ (1,9cm)
Weight: 2 LBS (0,9 Kg)



SPECIFICATIONS

Input Power:	9 amperes maximum at 7 volts DC nominal
Cooling Water Required:	400 milliliters per minute minimum at a maximum water temperature of approximately 20°C
Fluid Connections:	Accept ⅛″ I.D. flexible tubing

CAMBION P/N 806-1036 is a water cooled heating and cooling plate designed to control the environment for cell and tissue studies in which the EMF characteristics of the cells are observed. The present model is the result of an evolutionary series of designs, the first of which was developed for Dr. Eric Kandell of the New York University Medical School. This unit will hold the temperature of specimens either above or below ambient conditions within a range established by the associated temperature controller or power supply. The cooling/heating plate is totally isolated from the electrical power input and there is no vibration introduced from the fluid flow. A .50″ (12,7mm) diameter through-hole is provided for the transmission of light through the stage. Four different configurations of the 806-1036 are available to facilitate use with various power sources, temperature controllers, and readouts.

P/N 806-1036-01-00-00: Unit has two wire leads for connection to a fixed-output or variable power supply. There are no built-in thermistors in this P/N; overall temperature range of −20°C to +125°C is achievable.

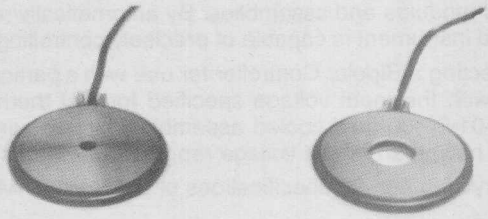
P/N 806-1036-02-00-00: Unit has a six-foot cable terminated with a connector which will mate with a CAMBION P/N 802-3970-01-00-00 variable power supply. There are no built-in thermistors in this P/N; overall temperature range of −20°C to +125°C is achievable.

P/N 806-1036-03-00-00: Unit has a six-foot cable terminated with a connector which will mate with a CAMBION P/N 809-3020-01-00-00 Bipolar Controller and contains built-in control thermistors. A 0°C to +50°C range is obtainable with this controller, and by adding a P/N 809-3048-01-00-00 Range Extender, a full −20°C to +125° range may be realized. Typical temperature stability is ±0.1°C.

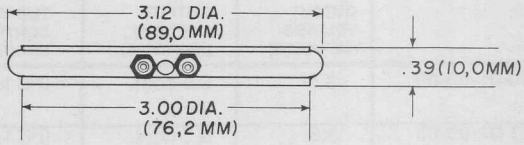
P/N 806-1036-04-00-00: Unit is similar to the P/N 806-1036-03-00-00 but contains an additional built-in temperature readout thermistor for use with a CAMBION P/N 811-7204-(01/02)-00-00 Digital Thermometer. NOTE: If a 0°C to +50°C range is required, this P/N is compatible with a P/N 809-3011-01-00-00 Bipolar Controller.

FLUID COOLED MICROSCOPE STAGES

PART NO'S. 806-2040-01-00-00 .25″ (6.35mm) dia. center hole
806-2040-02-00-00 .75″(19mm) dia. center hole
806-2040-03-00-00 no center through hole



CAMBION P/N 806-2040 Microscope Stage is a multi-purpose unit which may be used with a number of various microscopes. The stage is designed to be placed on top of the existing stage platform to control the temperature of specimens within a range determined by the associated temperature controller. Used for both heating and cooling, it can maintain specimen temperature for use in time lapse photography, biological specimen study, plus numerous other applications. Three models are available, two of which feature center through-holes for the transmission of light through the stage. All models have a six-foot electrical cable fitted with a connector which will mate with a compatible CAMBION Bipolar Temperature Controller.



SPECIFICATIONS

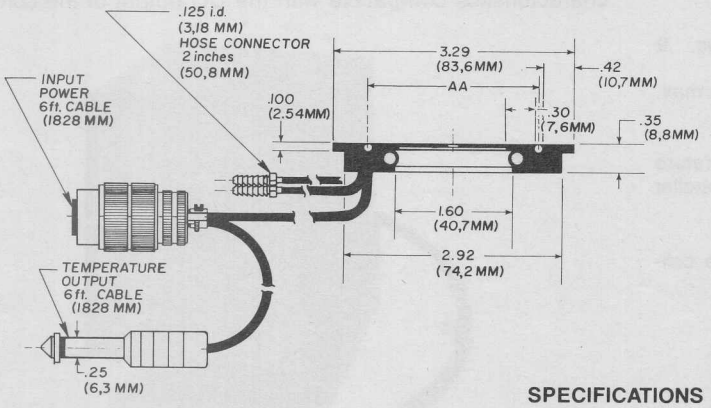
Input Power:	9 amperes maximum at 4 volts D.C. nominal
Heat Pumping Capacity:	15 watts (51 BTU/hr) at ambient temperature
Cooling Water Required:	500 milliliters per minute minimum at a maximum water temperature of approximately 20°C
Fluid Connections:	Accept ⅛″ I.D. flexible tubing
Compatible Temperature Controllers:	1) Temperature range of 0°C to +50°C: CAMBION P/N 809-3010-01-00-00 OR 809-3011-01-00-00 may be used; typical temperature stability of ±0.1°C 2) Temperature range of −20°C to +125°C: use CAMBION P/N 809-3020-01-00-00 Bipolar Controller together with P/N 809-3048-01-00-00 Range Extender: typical temperature stability of ±0.1°C
Compatible Temperature Readout:	CAMBION P/N 811-7204-(01/02)-00-00 Digital Thermometer

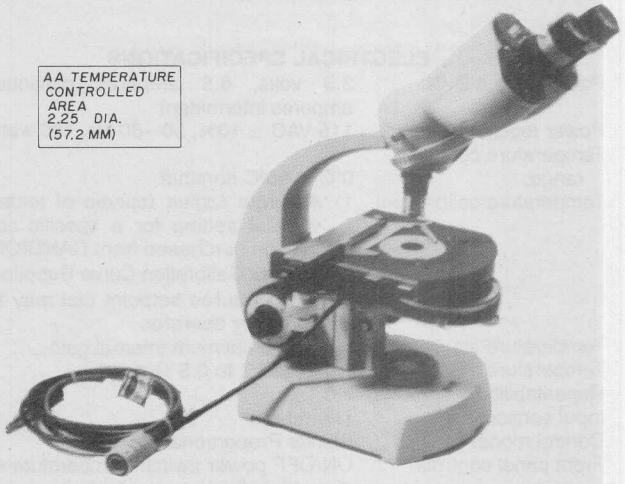
MICROSCOPE STAGE SUB-ASSEMBLY

PART NO. 806-2019-01-00-00

The CAMBION P/N 806-2019 is a temperature controlled microscope stage sub-assembly which is adaptable to a number of various microscopes by modifying the existing stage platform. A typical modification involves machining a through-hole and/or recess in the platform to allow the 806-2019 to be inserted so as to sit flush with the top of the platform. This modification is not possible on all microscopes, and complete technical information on your particular microscope should be supplied to CAMBION so that its feasibility can be determined. When this stage can be used, accurate temperature control of specimens may be obtained while maintaining excellent optical quality. The unit has a six-foot electrical cable fitted with a connector which will mate with a compatible CAMBION Bipolar Temperature Controller. Center through-hole is .25″ (6,35mm) diameter.

NOTE: A modified (BAKELITE) stage platform is available which will mount to a standard ZEISS upright Microscope. Consult CAMBION for further information.





SPECIFICATIONS

Input Power:	9 amperes maximum at 3.5 volts D.C. nominal
Cooling Water Required:	500 milliliters per minute minimum at a maximum water temperature of approximately 20°C
Compatible Temperature Controller:	1) Temperature range of 0°C to +50°C: CAMBION P/N 809-3010-01-00-00 *or* 809-3011-01-00-00 may be used; typical temperature stability of ±0.1°C 2) Temperature range of −10°C to +65°C; use CAMBION P/N 809-3020-01-00-00 together with P/N 809-3048-01-00-00 Range Extender; typical temperature stability of ±0.1°C
Compatible Temperature Readout:	CAMBION P/N 811-7204-(01/02)-00-00 Digital Thermometer

BIPOLAR TEMPERATURE CONTROLLERS

The CAMBION Bipolar Controller is an automatic temperature controlling unit which can be used in conjunction with various thermoelectric modules and assemblies. By automatically regulating the magnitude and direction of current flow through a thermoelectric device, the instrument is capable of precisely controlling the temperature of that device over a specific temperature range.

When selecting a Bipolar Controller for use with a particular thermoelectric module or assembly, the controller's output voltage must be matched with the input voltage specified for that thermoelectric device. For example, if a controller was needed to drive a model 806-1001-01-00-00 fluid cooled assembly which requires 9 amperes at 7 volts D.C. (nominal), a model 809-3020-01-00-00 Bipolar Controller having an output voltage range of 3 to 9 volts would be appropriate.

A summary of important specifications of standard CAMBION Bipolar Controllers is given in the table below.

PART NO.	OUTPUT VOLTAGE (DC VOLTS)	OUTPUT CURRENT (AMPERES)	TEMPERATURE CONTROL RANGE	TYPICAL TEMPERATURE STABILITY	RANGE EXTENDER CAPABILITY	AC INPUT POWER
809-3010-01-00-00	**3.5**	6.5 cont. 9 int.	0°C to +50°C	±0.1°C	no	115 VAC ±10% 50–60 Hz, 100 watts max.
809-3011-01-00-00	**3.5**	6.5 cont. 9 int.	0°C to +50°C	±0.1°C	no	115/230 VAC ±10% 50–60 Hz, 110 watts max.
809-3020-01-00-00	**3 to 9**	9	0°C to +50°C	±0.1°C	yes	115/230 VAC ±10% 50–60 Hz, 175 watts max.
809-3030-01-00-00	**10 to 15**	9	0°C to +50°C	±0.1°C	yes	115/230 VAC ±10% 50–60 Hz, 250 watts max.
809-3040-01-00-00	**14 to 34**	9	0°C to +50°C	±0.1°C	yes	115/230 VAC ±10% 50–60 Hz, 500 watts max.

SPECIAL BIPOLAR CONTROLLERS

In addition to the standard line of BIPOLAR CONTROLLERS shown above, CAMBION has developed a number of special controllers to meet specific customer requirements in quantities ranging from one unit to several hundred or more. Special controllers could take the form of slightly modified standard instruments or could include units of completely new electrical and/or mechanical design. Examples of special temperature controllers would include:

- Special temperature range
- Remote resistance programming
- Rack mounting
- Special output voltage or current
- Differential-type control
- Special package size or configuration
- Special input power requirements
- Linear control thermistor
- Built-in temperature readout
- Special paint or plating
- Special interfacing (cables, connectors, etc.)

PART NO.
809-3010-01-00-00

This controller will power any thermoelectric module which has characteristics compatible with the DC output of the controller.

ELECTRICAL SPECIFICATIONS

Power Output D.C.:	3.5 volts, 6.5 amperes continuous, 9 amperes intermittent
Power requirements:	115 VAC ± 10%, 50–60 Hz, 100 watts max.
Temperature control range:	0°C to 50°C nominal
Temperature calibration:	1) Accurate tables (curves of temperature vs. dial setting for a specific controller may be purchased from CAMBION. Typical Calibration Curve Supplied 2) Temperatures setpoint dial may be calibrated by operator.
Temperature stability:	±0.1°C at optimum internal gain
Temperature resolution:	0.018°C/div. to 0.3°C/div.
Repeatability:	±0.1°C
Input sensor:	Thermistor
Control mode:	Bipolar Proportional Control
Front panel controls:	ON/OFF power switch, temperature setpoint dial with indicator, setpoint lock.
Internal (Gain) control:	Factory set Potentiometer
Ambient temperature:	−10°C to 35°C (15°F to 95°F)
Height:	6.5″ (166mm)
Width:	5.5″ (160mm)
Depth:	11″ (280mm)
Weight:	8.7 lbs (3,95kg)

NOTES: • Also available for 220/240v, 50Hz operation — P/N 809-1018-01-00-00.
• The CAMBION P/N 809-3048-01-00-00 range extender may not be used with this controller

BIPOLAR CONTROLLERS

PART NO. 809-3011-01-00-00
PART NO. 809-3011-02-00-00

CAMBION P/N 809-3011 combines a P/N 809-3010-01-00-00 Bipolar Controller with a digital temperature readout in one neat and versatile package. This unit is especially useful in biological and research applications and will power any thermoelectric module or assembly which has electrical characteristics compatible with the DC output of the controller.

P/N 809-3011-02-00-00 features a BCD output from the temperature readout which may be used to drive a digital recorder or other device.

NOTE: The CAMBION P/N 809-3048-01-00-00 range extender may not be used with this controller

DIGITAL INDICATOR

Temperature indicator range:	−30°C to +50°C
Resolution:	0.1°C
Display:	3½ digit LED planar (0.5 inch nominal height); automatic polarity indication
Sampling rate:	Maximum conversion rate for unambiguous visual display; 2 conversions per second.
Conversion model:	Each conversion is totally independent of previous measurement and responds to step input in one conversion cycle.
Indicator accuracy:	@ 23°C for 6 months; better than 0.05% reading ± one count
Temperature coefficient:	Better than 0.005%/°C
Sensor:	Linear Thermistor
Overall accuracy:	±0.35°C or better
Height:	6.5″ (166mm)
Width:	8.3″ (211mm)
Depth:	11″ (280mm)
Weight:	10.7 lbs (4,85kg)

ELECTRICAL SPECIFICATIONS

Power output D.C.:	3.5 volts, 6.5 amp cont., 9 amp intermittent
Power requirements:	115/230 VAC 50−60 Hz, 110 watts max.
Temperature control range:	0°C to 50°C nominal
Temperature calibration:	1) Accurate tables (curves of temperature vs. dial setting for a specific controller may be purchased from CAMBION. Typical Calibration Curve Supplied 2) Temperature setpoint dial may be calibrated by operator.
Temperature stability:	±0.1°C at optimum internal gain
Temperature resolution:	0.018°C/div. to 0.3°C/div.
Repeatability:	±0.1°C
Input sensor:	Thermistor
Control mode:	Bipolar Proportional Control
Front panel controls:	ON/OFF power switch, temperature setpoint dial with indicator, setpoint lock
Internal (gain) control:	Factory set Potentiometer
Ambient temperature:	−10°C to 35°C (15°F to 95°F)

PART NO. 809-3020-01-00-00

Height:	6.5″ (166mm)
Width:	8.3″ (211mm)
Depth:	11″ (280mm)
Weight:	15.2 lbs. (6,9kg)

ELECTRICAL SPECIFICATIONS

Power output D.C.:	80 watts max., current limited at 9 amperes
Power requirements:	115/230 VAC ± 10%, 50−60 Hz, 175 watts max.
Temperature control range:	0°C to 50°C nominal; −20 to +125°C when used with CAMBION P/N 809-3048-01 range extender.
Temperature calibration:	1) Accurate tables (curves) of temperature vs. dial setting for a specific controller may be purchased from CAMBION. Typical Calibration Curve Supplied 2) Temperature setpoint dial may be calibrated by operator.
Temperature stability:	±0.1°C at optimum internal gain
Temperature resolution:	0.018°C/div. to 0.3°C/div.
Repeatability:	±0.05°C
Input sensor:	Thermistor
Control mode:	Bipolar Proportional Control
Front panel controls:	ON/OFF power switch, temperature setpoint dial with indicator, setpoint lock.
Internal (gain) control:	Factory set Potentiometer
Ambient temperature:	−10°C to 35°C (15°F to 95°F)

This controller will power any thermoelectric module or assembly requiring from 3 to 9 volts at 9 amperes maximum.

PART NO.
809-3030-01-00-00

This controller will power any thermoelectric module or assembly requiring from 10 to 15 volts at 9 amperes maximum.

ELECTRICAL SPECIFICATIONS

Power output D.C.:	130 watts max., current limited at 9 amperes
Power requirements:	115/230 VAC ± 10%, 50–60Hz, 250 watts max.
Temperature control range:	0°C to 50°C nominal; −20 to +125°C when used with CAMBION P/N 809-3048-01 range extender.
Temperature calibration:	1) Accurate tables (curves) of temperature vs. dial setting for a specific controller may be purchased from CAMBION. Typical Calibration Curve Supplied 2) Temperature setpoint dial may be calibrated by operator.
Temperature stability:	±0.1°C at optimum internal gain
Temperature resolution:	0.018°C/div. to 0.3°C/div.
Repeatability:	±0.05°C
Input sensor:	Thermistor
Control mode:	Bipolar Proportional Control
Front panel controls:	ON/OFF power switch, temperature setpoint dial with indicator, setpoint lock.
Internal (gain) control:	Factory set Potentiometer
Ambient temperature:	−10°C to 35°C (15°F to 95°F)

PHYSICAL CHARACTERISTICS

Height:	6.5″ (166mm)
Width:	8.3″ (211mm)
Depth:	11″ (280mm)
Weight:	16.3 lbs. (7,4kg)

PART NO.
809-3040-01-00-00

This controller will power any thermoelectric module or assembly requiring from 14 to 34 volts at 9 amperes maximum.

ELECTRICAL SPECIFICATIONS

Power output D.C.:	300 watts max., current limited at 9 amperes
Power requirements:	115/230 VAC ± 10%, 50–60Hz, 500 watts max.
Temperature control range:	0°C to 50°C nominal; −20 to +125°C when used with CAMBION P/N 809-3048-01 range extender.
Temperature calibration:	1) Accurate tables (curves) of temperature vs. dial setting for a specific controller may be purchased from CAMBION. Typical Calibration Curve Supplied 2) Temperature setpoint dial may be calibrated by operator.
Temperature stability:	±0.1°C at optimum internal gain
Temperature resolution:	0.018°C/div. to 0.3°C/div.
Repeatability:	±0.05°C
Input sensor:	Thermistor
Control mode:	Bipolar Proportional Control
Front panel controls:	ON/OFF power switch, temperature setpoint dial with indicator, setpoint lock.
Internal (gain) control:	Factory set Potentiometer
Ambient temperature:	−10°C to 35°C (15°F to 95°F)

PHYSICAL CHARACTERISTICS

Height:	8.3″ (210mm)
Width:	11.1″ (282mm)
Depth:	15.0″ (380mm)
Weight:	36 lbs. (16kg)

RANGE EXTENDER

PART NO.
809-3048-01-00-00

This Range Extender may be used in conjunction with the CAMBION 809-3000 series of Bipolar Controllers to expand the normal (0 to 50°C) temperature control range to a full −20 to +125°C. The unit requires no external power and plugs into a connector at the rear of the associated Bipolar Controller.

The Range Extender may be used with the following controllers:

809-3000-01-00-00
809-3020-01-00-00
809-3030-01-00-00
809-3040-01-00-00

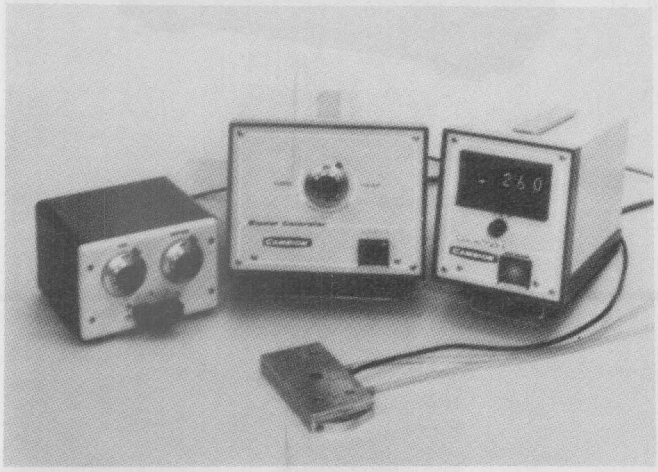
ELECTRICAL SPECIFICATIONS

Temperature control range:	−20°C to 125°C
Temperature calibration:	Temperature setpoint dial may be calibrated by operator; typical calibration curve supplied
Temperature stability:	±0.1°C typical
Temperature resolution:	0.018°C/div. to 0.3°C/div.
Repeatability:	±0.1°C
Input sensors:	Thermistor: (1 MEG) supplied with Range Extender (100K supplied with Bipolar Controller)
Control mode:	Bipolar Proportional Control
Front panel controls:	Low/Medium/High range push button switch, Setpoint Dials with Indicator Temperature Setpoint Lock
Interconnecting cable:	2 Ft. (610mm)
Ambient temperature operating:	−10°C to 35°C (15°F to 95°F)

PHYSICAL CHARACTERISTICS

Height:	4¼" (108mm)
Width:	6⅛" (155mm)
Depth:	5¾" (146mm)
Weight:	3 lbs. (1,36kg)

TYPICAL TEMPERATURE CONTROL SYSTEMS



SYSTEM CONSISTING OF:
809-3020-01-00-00 Bipolar Controller—Pages 14, 15
806-1036-04-00-00 Stage—Page 12
809-3048-01-00-00 Range Extender—Page **17**
811-7204-01-00-00 Digital Thermometer—Pages 21, 24

Using a "building block or modular approach, a wide variety of temperature control systems can be fabricated.

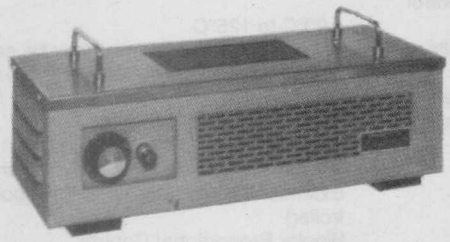
SYSTEM CONSISTING OF:
802-3970-01-00-00 Power Supply—Page 7
806-1036-02-00-00 Stage—Page 12
811-7207-01-00-00 Temperature Indicator—Page 20

SYSTEM CONSISTING OF:
809-3011-01-00-00 Bipolar Controller—Pages 14, 15
806-2040-02-00-00 Microscope Stage—Page 13

AUTOMATICALLY CONTROLLED LAB COLD AND HOT PLATE

PART NO. 811-7220-01-00-00

The CAMBION P/N 811-7220-01 is a self-contained laboratory hot and cold plate especially suitable for the temperature stabilization of components and biological specimens. Forced convection cooling is used for the internal thermoelectric modules thus eliminating the need for an external water source.



Controlled surface = 5.5″ × 2.5″

SPECIFICATIONS

Temperature control range:	−10°C to +50°C
Temperature stability:	±0.5°C typical
Heat pumping capacity:	40 watts maintained at ambient; 12 watts at 0°C
Input power:	115 VAC, 50−60 Hz, 300 watts maximum
Dimensions:	
Width:	7.3″ (18.4cm)
Height:	5.5″ (14.0 cm)
Length:	18″ (45.7cm)
Weight:	22 lbs (10kg)

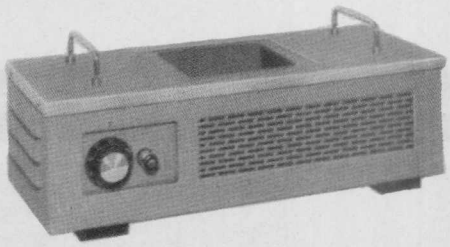
WATER COOLED AUTOMATICALLY CONTROLLED COLD AND HOT BATH

PART NO. 811-7222-01-00-00

The P/N 811-7222-01 is a temperature controlled bath ideally suited for medical and biological laboratory applications, for use as a reference source for gas traps, and for a wide variety of additional applications. The bath requires ordinary tap water for cooling of the internal thermoelectric components.

SPECIFICATIONS

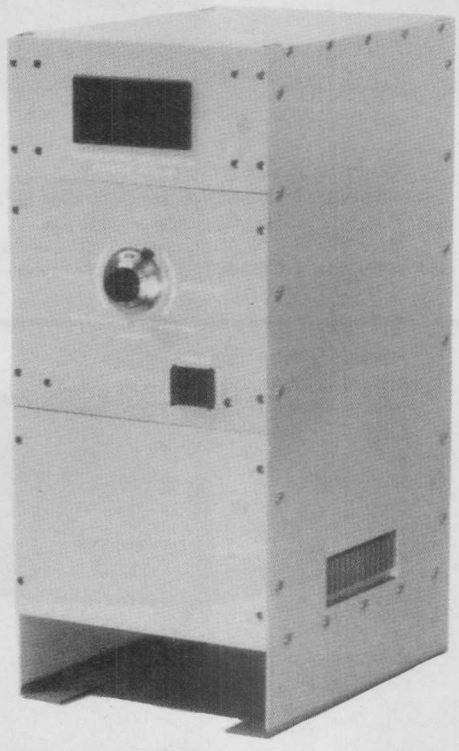
Temperature control range:	−10°C to +50°C
Temperature stability:	±0.2°C typical
Heat pumping capacity:	50 watts maintained at ambient; 15 watts at 0°C
Cooling water required:	600 milliliters per minute minimum at a maximum water temperature of approximately 20°C
Fluid connections:	Accept ¼″ O.D. copper tubing
Input power:	115 VAC, 50−60 Hz, 250 watts maximum
Bath chamber:	1400 milliliters capacity; chamber is Teflon coated
Weight:	23 lbs (10.5kg)

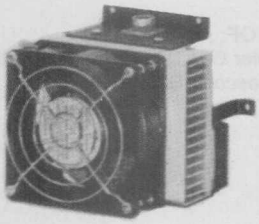


chamber size = 4.375″ × 5″ × 4″ deep

Shown below are examples of special Temperature Control Systems which have been designed and manufactured by Cambion. These devices are used as infrared calibration sources.

Our technical staff is available to assist you with your special temperature control requirements.





TEMPERATURE CONTROLLED BATHS

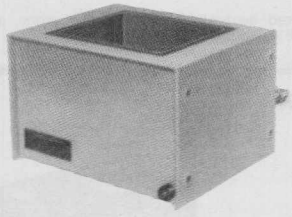
CAMBION has developed a line of small temperature controlled baths suitable for a wide variety of laboratory and process control applications. Both fluid cooled and forced convection models are available and a control accuracy of ±0.1°C or better is obtainable on all units. Bath chambers are Teflon coated for maximum corrosion resistance. In addition to the standard units illustrated, CAMBION has the capability of manufacturing special models to meet specific customer requirements.

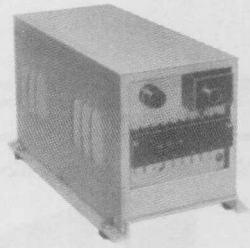
FLUID COOLED BATH

PART NO. 811-7224-02-00-00

SPECIFICATIONS

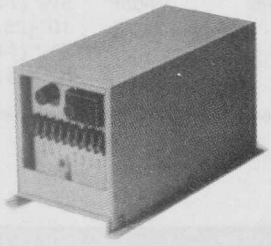
Chamber size:	4¼″ × 4¾″ × 4″ deep (10.8 × 12.1 × 10.2cm)
Chamber volume:	1400 milliliters nominal
Temperature control range:	−10°C to +40°C
Cooling water requirements:	600 milliliters per minute minimum at a maximum water temperature of approximately 20°C
Fluid connections:	Accept ¼″ O.D. copper tubing
Input power:	115 volts AC ±10%, 50−60 Hz, 300 watts maximum
Bath dimensions:	Width: 8″ (20.3cm)
	Depth: 6½″ (16.5cm)
	Height: 5″ (12.7cm)
	Weight: 10 lbs (4.5kg)
Controller dimensions:	Width: 5½″ (14.0cm)
	Depth: 10″ (25.4cm)
	Height: 5¾″ (14.6cm)
	Weight: 13 lbs (5.9kg)

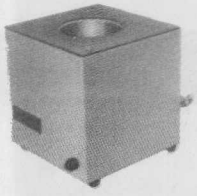




NOTE: Controller and bath may be ordered separately. For controller alone use P/N 809-7235-02-00-00. For bath alone use P/N 810-7283-01-00-00.

PART NO. 811-7225-02-00-00



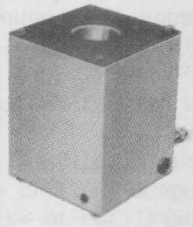


SPECIFICATIONS

Chamber size:	3″ (7.6cm) diameter × 4″ (10.2cm) deep
Chamber volume:	450 milliliters nominal
Temperature control range:	−10°C to +40°C
Cooling water requirements:	600 milliliters per minute minimum at a maximum water temperature of approximately 20°C
Fluid connections:	Accept ¼″ O.D. copper tubing
Input power:	115 volts AC ±10%, 50−60 Hz, 300 watts maximum
Bath dimensions:	6″ × 6″ × 6″ (15.2 × 15.2 × 15.2cm), Weight: 10 lbs (4.5kg)
Controller dimensions:	Width: 5½″ (14.0cm)
	Depth: 10″ (25.4cm)
	Height: 5¾″ (14.6cm)
	Weight: 13 lbs (5.9kg)

NOTE: Controller and bath may be ordered separately. For controller alone, use P/N 809-7235-02-00-00. For bath alone, use P/N 810-7286-01-00-00.

PART NO. 811-7226-02-00-00



SPECIFICATIONS

Chamber size:	1½″ (3.8cm) diameter × 3″ (7.6cm) deep
Chamber volume:	85 milliliters nominal
Temperature control range:	−10°C to +40°C
Cooling water requirements:	600 milliliters per minute maximum at a maximum water temperature of approximately 20°C
Fluid connections:	Accept ¼″ O.D. copper tubing
Input power:	115 volts AC ±10%, 50−60 Hz, 300 watts maximum
Bath dimensions:	5″ × 5″ × 5″ (12.7 × 12.7 × 12.7cm), Weight: 7.5 lbs (3.4kg)
Controller dimensions:	Width: 5½″ (14.0cm)
	Depth: 10″ (25.4cm)
	Height: 5¾″ (14.6cm)
	Weight: 13 lbs (5.9kg)

NOTE: Controller and bath may be ordered separately. For controller alone, use P/N 809-7235-02-00-00. For bath alone, use P/N 810-7285-01-00-00.

AIR COOLED BATH

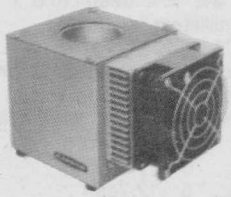
PART NO. 811-7227-02-00-00

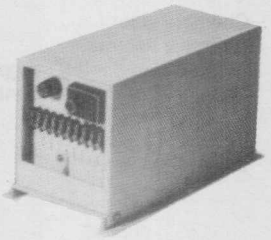
SPECIFICATIONS

Chamber size:	3″ (7.6cm) diameter × 4″ (10.2cm) deep
Chamber volume:	450 milliliters nominal
Temperature control range:	0°C to +40°C
Input power:	115 volts AC ±10%, 50–60 Hz, 300 watts maximum
Bath dimensions:	Width: 6″ (15.2cm)
	Depth: 9½″ (24.1cm)
	Height: 6½″ (16.5cm)
	Weight: 11 lbs (5.0kg)
Controller dimensions:	Width: 5½″ (14.0cm)
	Depth: 10″ (25.4cm)
	Height: 5¾″ (14.6cm)
	Weight: 13 lbs (5.9kg)

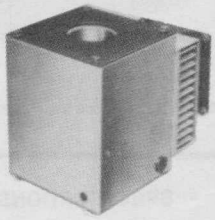
NOTE: Controller and bath may be ordered separately. For controller alone, use P/N 809-7235-02-00-00. For bath alone, use P/N 810-7288-01-00-00.

CAMBION **P/N 811-7227-02** is a solid bath with remote controller featuring forced convection cooling, and requiring no plumbing for heat dissipation. This unique solid bath is designed for source bottle configurations of 3″ diameter × 4″ deep. The bath is self-supporting and may be mounted conveniently on a shelf or furnace platform.





PART NO. 811-7228-02-00-00



CAMBION **P/N 811-7228-02** is a small solid bath with remote controller. This unique bath is designed for source bottles of 1½″ diameter × 3″ deep and features forced convection cooling allowing portability, ease and convenience of application. These features make this bath an interesting and useful addition to research laboratories where small specimen temperature control is required during investigations.

SPECIFICATIONS:

Chamber size:	1½″ (3.8cm) diameter × 3″ (7.6cm) deep
Chamber volume:	85 milliliters nominal
Temperature control range:	0°C to +40°C
Input power:	115 volts AC ±10%, 50–60 Hz, 300 watts maximum
Bath dimensions:	Width: 4″ (10.2cm)
	Depth: 7″ (17.8cm)
	Height: 5½″ (14.0cm)
Controller dimensions:	Width: 5½″ (14.0cm)
	Depth: 10″ (25.4cm)
	Height: 5¾″ (14.6cm)
	Weight: 5½ lbs (2.5kg)

NOTE: Bath may be ordered separately, use P/N 810-7287-01-00-00.

TEMPERATURE INDICATORS

ANALOG TEMPERATURE INDICATOR
PART NO. 811-7207-01/02/03-00-00

CAMBION P/N 811-7207-01, 811-7207-02 and 811-7207-03 are portable direct reading temperature instruments for laboratory and process control applications. Operating on 115 ac volt, 60 Hz input the above models draw approximately 10 watts of power. These devices are accurate to ±1% full scale.

CAMBION portable Temperature Indicators are a valuable addition to laboratory and process control areas where fluid bath and chamber temperatures require inexpensive temperature monitoring. This device is a portable useful tool no laboratory should be without.

P/N 811-7207-01 features a temperature range of −10°C to + 50°C (+15°F to +120°F). P/N's 811-7207-02 and 811-7207-03 are similar to P/N 811-7207-01 except that the temperature range is −50°C to +30°C (−65°F to +85°F), and 0°C to +100°C (32°F to +212°F) respectively.

Height:	4.44″	(11.3cm)
Width:	6.22″	(15.8cm)
Depth:	6.30″	(16.0cm)
Weight:	3 lbs	(1.36 Kg)

Each unit is provided with a flexible sealed thermistor probe having a 5′ cable

TEMPERATURE INDICATORS

PART NO. 811-7204-01/02-00-00

SPECIFICATIONS

Temperature range:	−30°C to +125°C in two ranges: (LOW) −30 to +50°C, (HIGH) +50 to +125°C
Accuracy:	±0.35°C worse case, ±0.2°C Typical
Digital output (-02 only):	BCD output. 3BCD 8-4-2-1 digit plus "1" range digit DTL/TTL CMOS compatible
Resolution:	0.1°C
Display:	3½ digit LED planar (0.5 inch nominal height); automatic polarity indication
Sampling rate:	Maximum conversion rate for unambiguous visual display; 2 conversions/sec.
Conversion mode:	Each conversion is totally independent of previous measurement and responds to step input in one conversion cycle
Indicator accuracy:	@ 23°C for 6 months; better than 0.05% reading ± one count.
Temperature coefficient:	Better than 0.001%/°C
Ambient operating temperature range:	−10°C to +50°C (15°F to 120°F)
Sensor:	Linear thermistor
Power requirements:	115/230 VAC ± 10%, 49−63 Hz, 4 watts max.
Dimensions:	Height: 6.6″ (168mm) Width: 5.5″ (139mm) Depth: 11.0″ (280mm) Weight: 5 lbs (2.3kg)

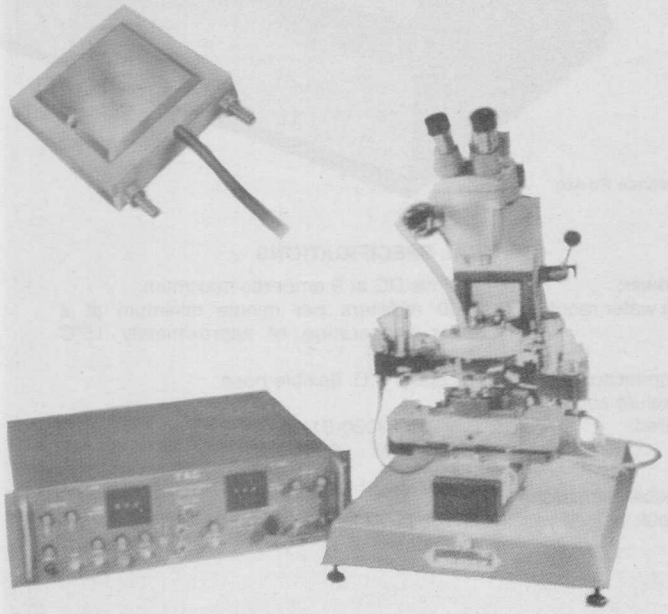
The CAMBION P/N 811-7204-(01/02) is a thermistor-type digital thermometer suitable for a wide variety of temperature measurement applications where moderate accuracy and resolution are required. The instrument is compatible with most CAMBION thermoelectric devices which incorporate a built-in thermistor readout sensor and may also be utilized in general measurement applications by using one of several available external probes. P/N 811-7204-02 features a digital output which may be used to drive a temperature recorder or other device.

WAFER PROBING STAGES

The development of profitable production of a variety of microcircuits dictate that accurate measurements be made of the electrical parameters of integrated circuits, thin films, thick films, and hybrid circuits.

Wafer probing instruments for this purpose with manual, semiautomatic and automatic indexing are in wide use throughout the semiconductor manufacturing and processing industry. The extent of the circuit data obtained is primarily dependent on the sophistication of the external test equipment, and to facilitate the obtaining of adequate data, CAMBION has developed a unique series of temperature controlled stations applicable to specific manufacture machines. All stations require tap-water cooling and feature a gold-plated wafer mounting surface. The models shown will directly interface with specific machines manufactured by Transistor Automation Corporation and Electroglas. In addition to the standard items illustrated, CAMBION has the capability of producing special devices for other probing machines or applications.

PART NO. 806-2006-01-00-00



Reference Photo

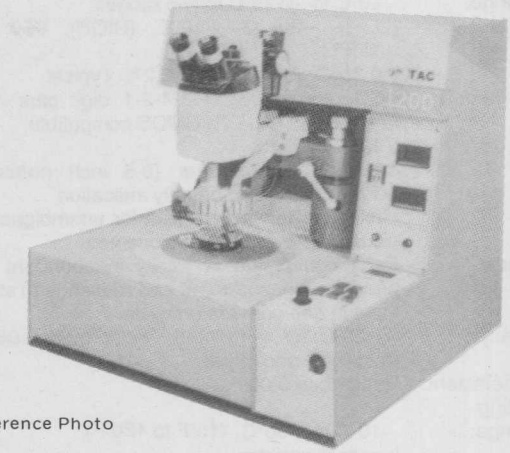
The CAMBION P/N 806-2006-01-00 is an automatic temperature controlled probing stage for 2 inch diameter wafers which will directly interface with Teledyne TAC XY-640S series prober machines. When used in conjunction with the appropriate control equipment, wafers may be tested over a temperature range of −20°C to +125°C with a typical stability of ±0.1°C. Wafer mounting surface is 2.06″ (52,3mm) square.

SPECIFICATIONS

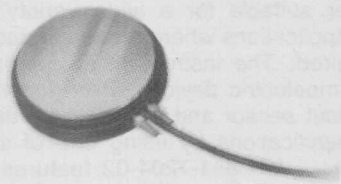
Input power:	3.5 volts DC at 9 amperes maximum
Cooling water required:	400 milliliters per minute minimum at a water temperature of approximately 20°C maximum
Fluid connections:	Accept ⅛″ I.D. flexible tubing
Temperature controller required:	**P/N** 809-3020-01-00-00 Bipolar Controller with model 809-3048-01-00-00 Range Extender
Compatible temperature readout:	**P/N** 811-7204-(01/02)-00-00 Digital Thermometer
Height:	0.67″ (1.7cm)
Width:	3.06″ (7.8cm)
Depth:	3.87″ (9.8cm)
Weight:	1.1 lbs (500gm)

PART NO. 812-7258-01-00-00

The CAMBION P/N 812-7258-01-00-00 is a wafer probing station for 3 inch diameter wafers designed specifically for use with TELEDYNE TAC XY-644T, 1200, PR-50/100/200/1206 probers. When used in conjunction with proper control and readout equipment, wafers may be tested over a temperature range of −20°C to +125°C with a typical stability of ±0.1°C.



Reference Photo



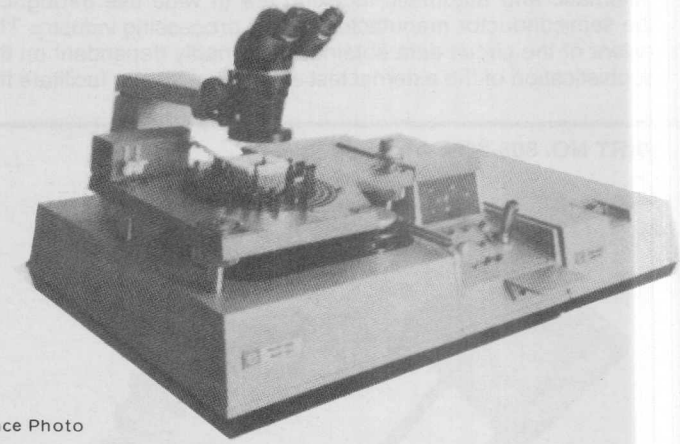
Height:	0.82″	(2.1cm)
Outside Diameter:	3.68″	(9.3cm)
Weight:	1.0 lbs	(455gm)

CRITICAL SPECIFICATIONS

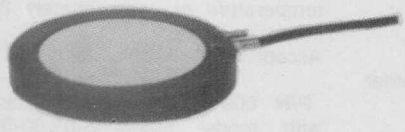
Input power:	5 volts DC at 9 amperes maximum
Cooling water required:	500 milliliters per minute minimum at a water temperature of approximately 20°C maximum
Fluid connections:	Accept ⅛″ I.D. flexible hose
Temperature controller required:	P/N 809-3020-01-00-00 Bipolar Controller with P/N 809-3048-01-00-00 Range Extender
Compatible temperature readout:	P/N 811-7204-(01/02)-00-00 Digital Thermometer

PART NO. 812-7262-01-00-00

The CAMBION P/N 812-7262-01-00-00 is a wafer probing chuck designed specifically for use with the ELECTROGLAS P/N 1031 and 1034 automatic wafer probers. With suitable mechanical interfacing, the chuck may also be used in other probing applications. Designed for use with up to 3½ inch diameter wafers, the device will facilitate wafer testing over a temperature range of −20°C to +125°C when used in conjunction with suitable control and readout equipment.



Reference Photo

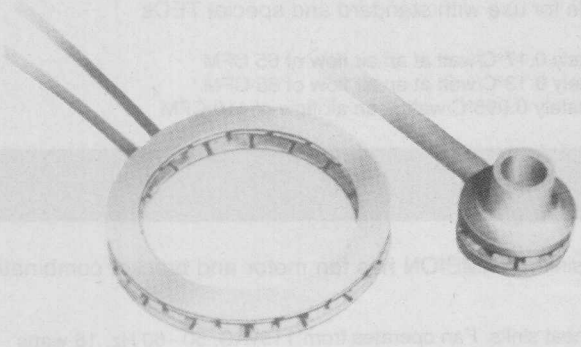


Height:	0.81″	(2.1cm)
Outside Diameter:	4.76″	(12.1cm)
Weight:	1.1 lbs	(500gm)

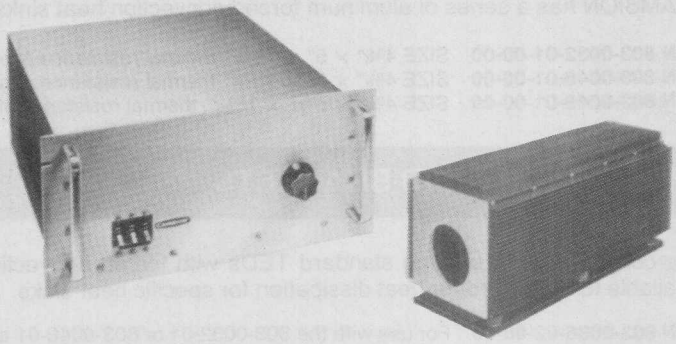
CRITICAL SPECIFICATIONS

Input power:	10 volts DC at 9 amperes maximum
Cooling water required:	1000 milliliters per minute minimum at a water temperature of approximately 15°C maximum
Fluid connections:	Accept ⅛″ I.D. flexible hose
Temperature controller required:	P/N 809-3030-01-00-00 Bipolar Controller with P/N 809-3048-01-00-00 Range Extender
Compatible temperature readout:	P/N 811-7204-(01/02)-00-00 Digital Thermometer

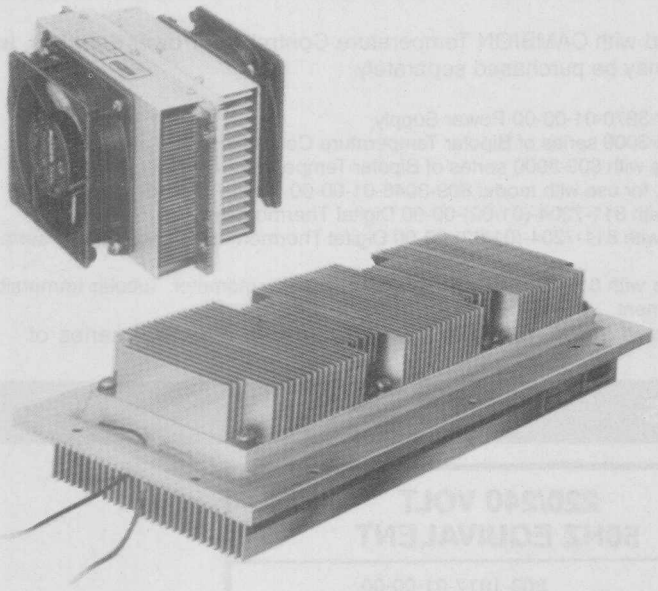
CUSTOM THERMOELECTRIC PRODUCTS MANUFACTURED BY CAMBION



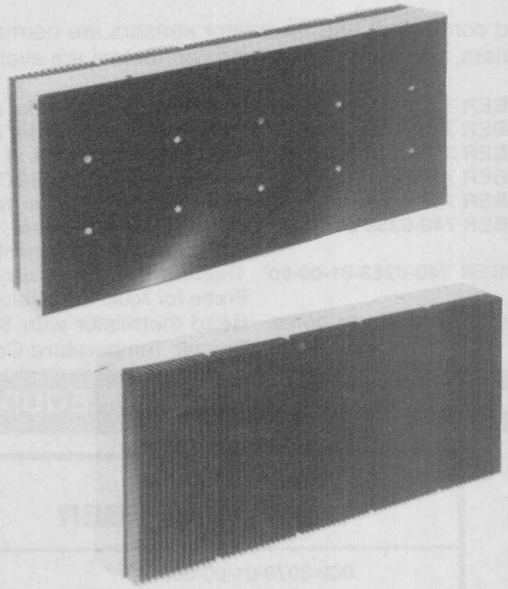
SPECIAL ANNULAR RING DEVICES CAN BE READILY FABRICATED UTILIZING PROPRIETARY CAMBION TECHNOLOGY



AIR COOLED ENVIRONMENTAL CHAMBER FOR A TELEVISION CAMERA



SPECIAL AIR TO AIR EXCHANGE SYSTEMS CAN EASILY BE SUPPLIED BY CAMBION FOR HIGH CAPACITY APPLICATIONS WITH OR WITHOUT POWER SUPPLIES AND TEMPERATURE CONTROLLERS



SPECIAL LOW TEMPERATURE DIFFERENTIAL POWER GENERATOR DEVELOPED FOR SINGLE HAND TRANS-ATLANTIC YACHT RACE.

ACCESSORIES AVAILABLE

THERMAL COMPOUND

A thermal interface compound is recommended for the hot and cold junctions of TEDs used in most applications. Zinc Oxide loaded Silicone grease having a thermal resistance of 0.05°C/watt/IN²/0.001″ film thickness is normally recommended.

PART NUMBER 630-7208-01-00-00 1 ounce jar
PART NUMBER 630-7208-02-00-00 2 ounce jar
PART NUMBER 630-7208-03-00-00 3 ounce jar

FLUID COOLED HEAT SINKS

CAMBION has available a series of fluid cooled heat sinks for use with standard and special TEDs. All models include fittings for ¼ inch I.D. hose.

P/N 806-0205-01-00-00 SIZE 1¼″ × 1¼″ × ½″, thermal resistance of 0.167°C/watt at a flow rate of 300 milliliters per minute.
P/N 806-0206-01-00-00 SIZE 3″ × 3″ × ½″, thermal resistance of 0.113°C/watt at a flow rate of 500 milliliters per minute.
P/N 806-0207-01-00-00 SIZE 3½″ × 5″ × ½″, thermal resistance of 0.077°C/watt at a flow rate of 800 milliliters per minute.
P/N 806-0208-01-00-00 SIZE 4¾″ × 7½″ × ½″, thermal resistance of 0.065°C/watt at a flow rate of 1000 milliliters per minute.
P/N 806-0210-01-00-00 SIZE 11″ × 13″ × ⅝″, thermal resistance of 0.050°C/watt at a flow rate of 1500 milliliters per minute.

FORCED CONVECTION HEAT SINKS

CAMBION has a series of aluminum forced convection heat sinks available for use with standard and special TEDs

P/N 803-0032-01-00-00 SIZE 4⅜″ × 5″ × $1^{5}/_{16}$″, thermal resistance of approximately 0.17°C/watt at an air flow of 65 CFM
P/N 803-0046-01-00-00 SIZE 4⅜″ × 8″ × $1^{5}/_{16}$″, thermal resistance of approximately 0.13°C/watt at an air flow of 65 CFM
P/N 803-0049-01-00-00 SIZE 4¾″ × 8½″ × $1^{5}/_{16}$″, thermal resistance of approximately 0.095°C/watt at an air flow of 110 CFM

FAN MOTORS AND BRACKETS

For convenience in utilizing standard TEDs with forced convection heat sinks, CAMBION has fan motor and bracket combinations available to insure proper heat dissipation for specific heat sinks.

P/N 803-0036-02-00-00 For use with the 803-0032-01 or 803-0046-01 aluminum heat sinks. Fan operates from 115VAC, 50–60 Hz, 16 watts
P/N 803-0215-02-00-00 For use with the 803-0049-01 aluminum heat sink. Fan operates from 115VAC, 50–60 Hz, 23 watts.

THERMISTORS AND CONNECTORS

All required connectors and thermistor sensors are normally supplied with CAMBION Temperature Controllers, Power Supplies, and Thermometers. Extra thermistors and connectors are available and may be purchased separately.

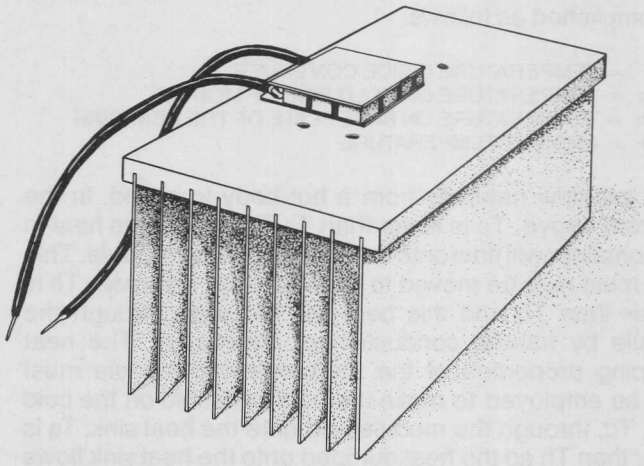
PART NUMBER 740-0065-01-00-00 Connector, 5-pin male for use with 802-3970-01-00-00 Power Supply
PART NUMBER 740-0239-03-00-00 Connector, 5-pin male for use with 809-3000 series of Bipolar Temperature Controllers
PART NUMBER 740-0040-08-00-00 Bead Thermistor, 100K at 25°C, for use with 809-3000 series of Bipolar Temperature Controllers
PART NUMBER 740-0040-10-00-00 Bead Thermistor, 1 MEGOHM at 25°C, for use with model 809-3048-01-00-00 Range Extender
PART NUMBER 740-0158-01-00-00 Bead Thermistor, Linear-type for use with 811-7204-(01/02)-00-00 Digital Thermometer
PART NUMBER 740-0259-01-00-00 Thermistor Probe, Linear-type for use with 811-7204-(01/02)-00-00 Digital Thermometer. Disk probe for surface temperature measurement
PART NUMBER 740-0263-01-00-00 Thermistor Probe, Linear-type for use with 811-7204-(01/02)-00-00 Digital Thermometer. Tubular Immersible Probe for liquid temperature measurement.
PART NUMBER 740-0324-01-00-00 Bead thermistor with 6 foot insulated leads, 100 K at 25°C for use with 809-3000 series of Bipolar Temperature Controllers

115 VOLT P/N AND 220/240 VOLT EQUIVALENTS

115 VOLT NUMBER	220/240 VOLT 50HZ EQUIVALENT
802-3970-01-00-00	802-1017-01-00-00
802-3971-01-00-00	802-1000-01-00-00
802-3972-01-00-00	802-1001-01-00-00
★ 802-7230-01-00-00	★ 802-7230-01-00-00
803-1004-01-00-00	803-1009-01-00-00
803-1010-01-00-00	803-1007-01-00-00
803-1011-01-00-00	803-1008-01-00-00
809-3010-01-00-00	809-1018-01-00-00
★ 809-3011-01/02-00-00	★ 809-3011-01/02-00-00
★ 809-3020-01-00-00	★ 809-3020-01-00-00
★ 809-3030-01-00-00	★ 809-3030-01-00-00
★ 809-3040-01-00-00	★ 809-3040-01-00-00
809-7235-02-00-00	809-1016-02-00-00
★ 811-7204-01/02-00-00	★ 811-7204-01/02-00-00

★Operates on both voltages

INSTALLATION OF THERMOELECTRIC MODULES



Thermoelectric devices are only as strong as the semiconductor materials used in their fabrication and thus may be damaged by the application of excessive stress. Modules should never be designed as mechanical supporting members of an assembly.

Several mounting methods are available including the clamping of modules between a heat sink and object to be cooled and the soldering or epoxy bonding of the module hot side to a heat sink. Mechanical clamping is generally the preferred mounting technique and soldering is normally used only when other methods are not practical. Epoxy bonding should not be used when operation in a vacuum is required.

CLAMPING METHOD

1) The mounting surfaces between which modules are to be clamped should be ground or lapped flat to within ±.001″.
2) Clean module and mounting surfaces carefully to remove any burrs, grit, etc.
3) If more than one module is to be used in the assembly, all modules in the set must be matched in thickness (height) to within .002″ total deviation.
4) Coat the module hot-side with a thin film (.001″ typical thickness) of Zinc Oxide loaded Silicone grease (such as CAMBION P/N 630-7208-01-00-00, DOW CORNING type 340, WAKEFIELD type 120, or GE type G641) and place the module on the heat sink. Applying firm but even downward pressure, rock the module from side to side until a slight resistance is felt and excess thermal grease is squeezed out.
5) Coat the cold side of the module with a thin film of thermal grease. Place the object to be cooled in contact with the module and rock the object slightly from side to side to squeeze out excess thermal grease.
6) Bolt the object to be cooled and heat sink together using 4-40 or 6-32 stainless steel screws with Belleville washers or split-type lockwashers. To insure even pressure across the module surfaces, tighten all screws "finger tight" and then continue tightening in an alternate or crosswise pattern starting with center screws (if any) first. Repeat this pattern several times, gradually increasing torque each time. A simple method of estimating correct screw torque is to bring all screws down until they are "snug" (but not tight) and back off approximately one-quarter turn so that the spring action of the belleville washer or split lockwasher can be felt. Maximum recommended compression loading is 15 pounds per square inch of module surface.

EPOXY BONDING METHOD

1) Grind or lap the heat sink surface flat and clean and degrease to remove any burrs, oil, grit, etc.
2) Coat the module hot side with a thin layer of thermally conductive epoxy (such as WAKEFIELD "Delta Bond 152").
3) Place the module on the heat sink and rock slightly from side to side until resistance is felt and excess epoxy is squeezed out.
4) Weight or lightly clamp the module to hold it in place until the thermal epoxy has cured.

SOLDERING METHOD

CAUTION: This procedure entails some risk of module damage during installation and moderately close temperature control is required in order to prevent overheating of the module. Other mounting methods should be used whenever possible.

1) Grind or lap the heat sink surface flat and clean and degrease to remove any foreign matter. The heat sink surface must be solderable. I.e., either copper or properly plated aluminum.
2) Tin the module area of the heat sink with a low temperature solder which has a melting point below 125°C. Heat the heat sink surface to 120 to 130°C. Apply flux to the copper pads on the module hot side and place the module in position on the tinned heat sink. Move the module slightly in a circular pattern and, after a few seconds, the solder should wet the module. Surface and excess flux will boil out. NOTE: Any significant resistance to module movement on the heat sink indicates insufficient solder. In this event, remove the module and add additional solder to the heat sink.
3) Allow the assembly to cool and remove all flux residue.

The function of a thermoelectric module is simply to pull heat out of one area and deposit it in another. This is accomplished as follows:

Ti = TEMPERATURE INSIDE CONTAINER
Tc = TEMPERATURE ON COLD SIDE OF MODULE
Th = TEMPERATURE ON BASE PLATE OF THE HEAT SINK
Ta = AMBIENT TEMPERATURE

Heat will flow naturally from a hot body to a cold. In the diagram above, Tc is lower than Ti. Therefore, the heat in the container will flow onto the cold side of the module. This heat must now be moved to the heat sink. However, Th is higher than Tc and this heat will not pass through the module by natural conduction or convection. The heat pumping properties of the thermoelectric module must now be employed to move the heat collected on the cold side, Tc, through the module and onto the heat sink. Ta is lower than Th so the heat dumped onto the heat sink flows out into the ambient by natural (or forced) convection. Heat flows naturally to the surface of the module and off the heat sink, but thermoelectric pumping must be used to transfer the heat on one side of the module to the other.

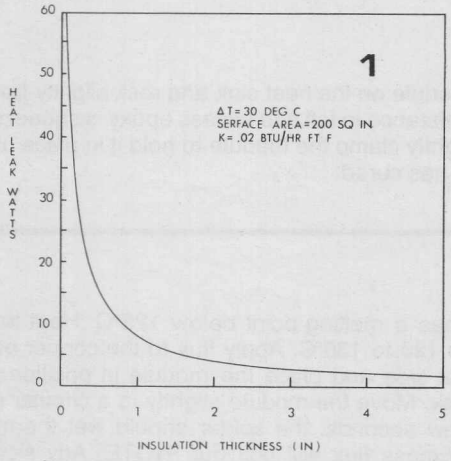
CALCULATION OF HEAT LOAD

When trying to determine the heat pumping capacity required, two factors must be considered; *Active Heating Elements* and *Heat Leak.*

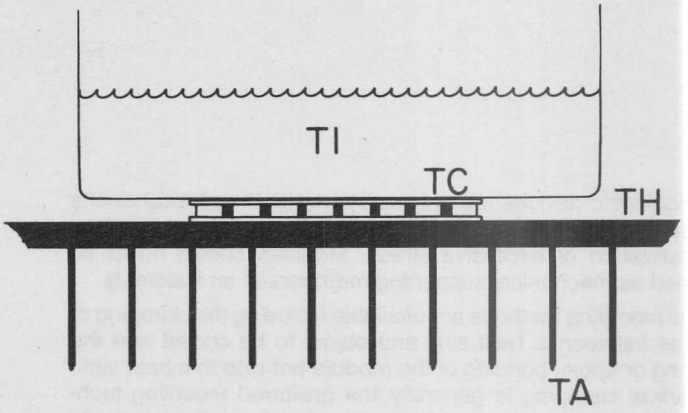
Active Heating Elements are any components on the cold surface which have a power consumption. All of this power consumption (input power) will eventually be converted to heat and should be considered as heat load.

An object which is at a temperature below ambient will draw heat from the surroundings onto its cold surface. The results of this additional heat is that a cold container which is not insulated will not be able to maintain temperatures as low as one which has insulation. This additional heat is called the *heat leak.* In many applications, heat leak is the major consideration.

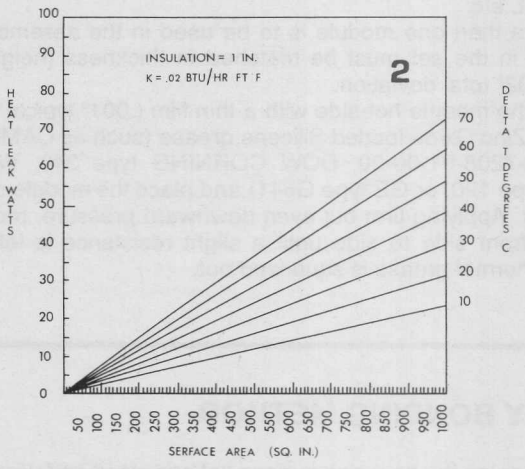
The total heat pumping capacity required is the sum of the active heat load and the heat leak.

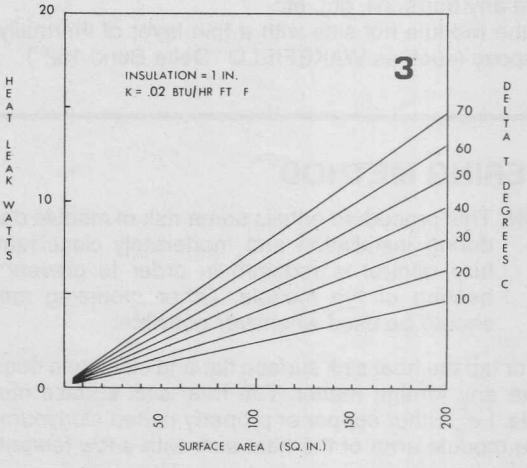


Graph #1 shows how heat leak is affected by insulation. Notice how one inch makes a drastic reduction in the amount of heat leak while additional insulation has little effect.



The three main factors used in calculating heat leak are: the temperature difference between ambient and the inside of the container, the surface area of the container, and the amount of insulation used. As can be seen from Graph #1, one inch of insulation is usually a good choice. Using Graph #2 and #3, which assume one inch of polyurethane insulation, heat leak can be estimated. The total surface area of the container is plotted against the amount of heat leak. The different curves are for various temperature differences between ambient temperature and the inside temperature of the container. These temperature differences are listed in degrees Centigrade.





There are other sources of heat leak such as conduction heat from electrical wires or heat leak from the heat sink back to the cold plate. Therefore, quantities of heat leak found from these graphs are only approximations. Cambion's engineering staff is prepared to assist you in making the exact calculations necessary for actual design.

CHOOSING THE PROPER HEAT SINK

Once the required heat pumping capacity has been determined the next step is choosing the proper heat sink. A thermoelectric module is not a sponge which absorbs heat, rather, it is a heat pump. The heat which is pumped out of the cold surface is deposited on the hot side of the module. This heat must be dissipated in some way. If not, the hot side of the module will heat up to the point where it will stop functioning as a cooling device and actually begin to heat the cold surface.

As seen in the SUMMARY OF COOLING BY THERMOELECTRICS section, a heat sink must be maintained at a temperature higher than ambient to transfer heat from its surface out into the surroundings. The higher Th is above Ta the more heat can be transferred out of the heat sink. This points to choosing a heat sink which will get as hot as possible. However, recall the performance curves of a module. Since the hot side of a thermoelectric module is at almost the same temperature as the heat sink, it will heat up as Th increases. As Th increases, the delta T across the module becomes larger and both the heat pumping capacity and the efficiency (C.O.P.) of the module decrease. Considering both these phenomena, a heat sink which rises to a temperature between 5 and 15 degrees Centigrade above ambient is a practical choice.

Heat sinks are rated in Deg. C/Watt. This is a measure of how many degrees the heat sink will rise above ambient when one watt of heat is pumped onto its surface. For example a heat sink rated at .17°C/Watt will rise to a temperature 17°C above ambient when a heat load of 100 watts is dumped onto its surface.

There is a multitude of heat sinks but for normal applications there are only three main classifications; *natural convection, forced convection,* and *liquid cooled.* Depending on size and configuration each of these three types can be given virtually any Deg. C/Watt rating. However, as a rule of thumb natural convection can be expected to be about 2.0 to .5°C/Watt, forced convection 0.5 to 0.02°C/Watt and liquid cooled 0.02 to 0.005°C/Watt. Depending on the heat load which must be dissipated one or all three types are reasonable options. However, it will generally be found that natural convection heat sinks are not adequate for most thermoelectric applications.

INTERPRETATION OF TABULATED DATA

The performance graph* given for the 801-2001-01-00-00 can be used to check the performance of any module by multiplying the graphed performance by the appropriate Qc factor. If you require data at some point other than Th = 50°C the data tabulated on the next pages must be used. Each section lists Th and DT on the top line. Th is the temperature of the hot side of the module and DT is the temperature difference across the module. I is the input current, V the input voltage and P the total input power. COPR is the efficiency of the module as a refrigerator, Qh (O)is the total heat load which must be dissipated out of the module and Qc (I) is the total heat load pumped into the cold side of the module. Qh is always greater than Qc because the heat sink must dissipate not only the heat pumped out of the cold surface but also the electrical power which is input to the module to perform the heat pumping.

The following example demonstrates use of the tabulated data. It is desired to maintain a surface at 28°C in an ambient of 55°C. The total heat load is determined to be 15 watts. Choosing a heat sink which will operate at 5°C above ambient indicates use of the data below.

TH = 60.0 C	DT = 32.0 C									
I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.7	4.1	4.5
P	0.8	2.4	4.8	8.1	12.1	17.0	22.7	29.2	36.6	44.7
QH(O)	- 2.2	2.4	7.4	12.9	18.7	25.0	31.6	38.7	46.2	54.1
QC(I)	- 3.0	-.0	2.6	4.8	6.6	8.0	8.9	9.5	9.6	9.4
COPR	-379	0	53	59	54	46	39	32	26	21
COPH	-279	99	153	159	154	146	139	132	126	121

Th = Ta + 5 = 60°C DT = Th − Tc = 60 − 28 = 32°C

One module at I = 6 amps will pump 8.0 watts; therefore, two modules both operating at 6 amps should be used. Qh for one module is 25 watts so the total Qh on the heat sink is 50 watts. To dissipate this heat, and maintain the heat sink at the required temperature, a heat sink rated at 5°C/50 watts or 0.10°C/Watt is necessary.

The cooling power of a thermoelectric module is directly proportional to the number of couples and the maximum current of the module.

To find the cooling power of a particular module other than the 801-2001-01 from the tabulated data, a few simple conversions must be performed.

Qc = Qc (from the table) × Qc factor

The performance of a 7 amp maximum module operating at 3 amps is very different from a 14 amp maximum module at the same current. To convert the current prescribed by the table into the current which should be input to the new module, use

$$I\,(\text{new}) = \frac{I\,(\text{from the table})}{9\,(I\ \text{max for 801-2001})} \times I\ \text{max (for new module)}$$

For example, 3 amps from the table corresponds to 2 amps in an 801-2003-01, this is found as

$$I = \frac{3}{9} \times 6 = 2,$$

and 4.7 amps in a 801-1081-01. The new operating voltage is found as:

V (new) = V (from the table) × N/31 where N is the number of couples in the new module.

These pages have been included to give a better understanding of cooling by thermoelectrics. If any questions arise while going through this material, please call. If, after reading this brochure, thermoelectrics appears to be the answer to some of your design needs, our engineering staff is ready to assist in choosing the correct standard product or to design a new system to meet your requirements.

*see page 6

SUMMARY OF COOLING BY THERMOELECTRICS

*TH = 20.0 C DT = 0.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.4	0.7	1.1	1.4	1.8	2.2	2.5	2.9	3.3	3.6
P	0.4	1.4	3.3	5.8	9.0	13.0	17.7	23.2	29.3	36.2
QH(O)	3.6	7.6	11.9	16.6	21.6	27.0	32.8	38.9	45.4	52.2
QC(I)	3.2	6.1	8.6	10.8	12.5	14.0	15.0	15.7	16.1	16.0
COPR	893	421	264	185	138	107	84	67	54	44
COPH	993	521	364	285	238	207	184	167	154	144

TH = 20.0 C DT = 8.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.4	0.8	1.2	1.5	1.9	2.2	2.6	2.9	3.3	3.6
P	0.4	1.6	3.5	6.0	9.3	13.3	18.0	23.4	29.5	36.4
QH(O)	2.1	6.0	10.3	14.9	19.9	25.2	30.9	37.0	43.4	50.1
QC(I)	1.6	4.4	6.8	8.9	10.6	11.9	12.9	13.5	13.8	13.8
COPR	367	274	196	146	113	89	71	57	46	37
COPH	467	374	296	246	213	189	171	157	146	137

TH = 20.0 C DT = 16.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.5	0.9	1.2	1.6	1.9	2.3	2.6	3.0	3.3	3.7
P	0.5	1.8	3.7	6.3	9.6	13.6	18.3	23.7	29.8	36.5
QH(O)	0.6	4.5	8.7	13.3	18.2	23.5	29.1	35.1	41.4	48.0
QC(I)	.1	2.7	5.0	7.0	8.6	9.9	10.8	11.4	11.6	11.5
COPR	13	155	137	111	89	72	59	48	38	31
COPH	113	255	237	211	189	172	159	148	138	131

TH = 20.0 C DT = 24.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.6	1.0	1.3	1.6	2.0	2.3	2.7	3.0	3.3	3.7
P	0.6	1.9	3.9	6.5	9.9	13.9	18.6	23.9	30.0	36.7
QH(O)	-0.9	3.0	7.1	11.7	16.5	21.7	27.3	33.1	39.4	45.9
QC(I)	- 1.5	1.1	3.3	5.1	6.7	7.8	8.7	9.2	9.4	9.2
COPR	-244	55	84	78	67	56	46	38	31	25
COPH	-144	155	184	178	167	156	146	138	131	125

TH = 20.0 C DT = 32.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.7	1.0	1.4	1.7	2.0	2.4	2.7	3.0	3.4	3.7
P	0.7	2.1	4.1	6.8	10.1	14.1	18.8	24.2	30.2	36.9
QH(O)	- 2.4	1.4	5.6	10.0	14.8	20.0	25.4	31.2	37.3	43.8
QC(I)	- 3.1	-0.6	1.5	3.3	4.7	5.8	6.6	7.0	7.2	6.9
COPR	-442	-30	36	48	46	41	35	29	23	18
COPH	-342	69	136	148	146	141	135	129	123	118

TH = 20.0 C DT = 40.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.8	1.1	1.4	1.7	2.1	2.4	2.7	3.1	3.4	3.7
P	0.8	2.2	4.3	7.0	10.4	14.4	19.1	24.4	30.4	37.0
QH(O)	- 3.9	-0.1	4.0	8.4	13.1	18.2	23.6	29.3	35.3	41.7
QC(I)	- 4.6	- 2.3	-0.3	1.4	2.8	3.8	4.5	4.9	4.9	4.7
COPR	-600	-104	-6	19	26	26	23	19	16	12
COPH	-500	-4	93	119	126	126	123	119	116	112

TH = 20.0 C DT = 48.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.8	1.2	1.5	1.8	2.1	2.4	2.8	3.1	3.4	3.7
P	0.8	2.3	4.5	7.2	10.6	14.7	19.3	24.6	30.6	37.2
QH(O)	- 5.4	- 1.7	2.4	6.7	11.4	16.4	21.7	27.3	33.3	39.6
QC(I)	- 6.2	- 4.0	- 2.1	-0.5	0.8	1.7	2.4	2.7	2.7	2.4
COPR	-733	-170	-46	-6	7	11	12	10	8	6
COPH	-633	-70	53	93	107	111	112	110	108	106

TH = 20.0 C DT = 56.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.9	1.2	1.5	1.9	2.2	2.5	2.8	3.1	3.4	3.7
P	0.9	2.5	4.6	7.4	10.9	14.9	19.6	24.9	30.8	37.3
QH(O)	- 6.9	- 3.2	0.8	5.1	9.7	14.6	19.8	25.4	31.3	37.4
QC(I)	- 7.8	- 5.7	- 3.9	- 2.4	- 1.2	-0.3	0.3	0.5	0.5	.1
COPR	-846	-230	-83	-31	-10	-2	1	2	1	0
COPH	-746	-130	16	68	89	97	101	102	101	100

*TH = 30.0 C DT = 0.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.4	0.8	1.1	1.5	1.9	2.3	2.7	3.0	3.4	3.8
P	0.4	1.5	3.4	6.1	9.5	13.7	18.7	24.4	30.9	38.1
QH(O)	3.8	7.9	12.5	17.4	22.7	28.4	34.5	40.9	47.8	55.0
QC(I)	3.4	6.4	9.1	11.3	13.2	14.7	15.8	16.5	16.9	16.9
COPR	892	421	264	185	138	107	84	67	54	44
COPH	992	521	364	285	238	207	184	167	154	144

TH = 30.0 C DT = 8.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.5	0.8	1.2	1.6	2.0	2.3	2.7	3.1	3.5	3.8
P	0.5	1.7	3.6	6.4	9.8	14.0	19.0	24.7	31.1	38.3
QH(O)	2.2	6.4	10.9	15.7	21.0	26.6	32.6	39.0	45.7	52.8
QC(I)	1.8	4.7	7.2	9.4	11.2	12.6	13.7	14.3	14.6	14.6
COPR	380	278	198	147	114	90	72	58	47	38
COPH	480	378	298	247	214	190	172	158	147	138

TH = 30.0 C DT = 16.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.6	0.9	1.3	1.7	2.0	2.4	2.7	3.1	3.5	3.8
P	0.6	1.8	3.9	6.6	10.1	14.3	19.2	24.9	31.3	38.5
QH(O)	0.7	4.8	9.3	14.1	19.3	24.8	30.8	37.1	43.7	50.7
QC(I)	0.2	3.0	5.4	7.5	9.2	10.6	11.5	12.1	12.4	12.3
COPR	33	162	140	113	91	73	59	48	39	31
COPH	133	262	240	213	191	173	159	148	139	131

TH = 30.0 C DT = 24.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.6	1.0	1.4	1.7	2.1	2.4	2.8	3.1	3.5	3.9
P	0.6	2.0	4.1	6.8	10.3	14.6	19.5	25.2	31.5	38.6
QH(O)	-0.8	3.3	7.7	12.5	17.6	23.1	28.9	35.1	41.7	48.6
QC(I)	- 1.4	1.3	3.6	5.6	7.3	8.5	9.4	10.0	10.2	10.0
COPR	-218	65	89	82	70	58	48	39	32	25
COPH	-118	165	189	182	170	158	148	139	132	125

TH = 30.0 C DT = 32.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.7	1.1	1.4	1.8	2.1	2.5	2.8	3.2	3.5	3.9
P	0.7	2.1	4.3	7.1	10.6	14.8	19.8	25.4	31.7	38.8
QH(O)	- 2.2	1.8	6.1	10.8	15.9	21.3	27.1	33.2	39.7	46.5
QC(I)	- 3.0	-0.4	1.9	3.8	5.3	6.5	7.3	7.8	7.9	7.7
COPR	-411	-17	43	53	49	43	37	30	25	19
COPH	-311	82	143	153	149	143	137	130	125	119

TH = 30.0 C DT = 40.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.8	1.1	1.5	1.8	2.2	2.5	2.9	3.2	3.5	3.9
P	0.8	2.3	4.5	7.3	10.9	15.1	20.0	25.6	31.9	38.9
QH(O)	- 3.7	0.2	4.6	9.2	14.2	19.6	25.3	31.3	37.7	44.4
QC(I)	- 4.5	- 2.0	.1	1.9	3.4	4.5	5.2	5.6	5.7	5.5
COPR	-565	-89	2	25	30	29	26	22	17	14
COPH	-465	10	102	125	130	129	126	122	117	114

TH = 30.0 C DT = 48.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.9	1.2	1.6	1.9	2.2	2.6	2.9	3.2	3.6	3.9
P	0.9	2.4	4.7	7.6	11.1	15.4	20.3	25.9	32.1	39.1
QH(O)	- 5.2	- 1.3	3.0	7.6	12.5	17.8	23.4	29.4	35.6	42.3
QC(I)	- 6.1	- 3.7	- 1.7	.0	1.4	2.4	3.1	3.5	3.5	3.2
COPR	-693	-152	-35	0	12	15	15	13	10	8
COPH	-593	-52	64	100	112	115	115	113	110	108

TH = 30.0 C DT = 56.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	1.0	1.3	1.6	1.9	2.3	2.6	2.9	3.3	3.6	3.9
P	1.0	2.6	4.8	7.8	11.4	15.6	20.5	26.1	32.3	39.2
QH(O)	- 6.7	- 2.8	1.4	5.9	10.8	16.0	21.6	27.4	33.6	40.1
QC(I)	- 7.7	- 5.4	- 3.5	- 1.8	-0.6	0.4	1.0	1.3	1.3	0.9
COPR	-802	-210	-71	-23	-4	2	4	5	3	2
COPH	-702	-110	28	76	95	102	104	105	103	102

TH = 30.0 C DT = 60.8 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	1.0	1.3	1.7	2.0	2.3	2.6	3.0	3.3	3.6	3.9
P	1.0	2.7	5.0	7.9	11.5	15.8	20.7	26.2	32.5	39.3
QH(O)	- 7.6	- 3.8	0.4	4.9	9.8	14.9	20.4	26.3	32.4	38.9
QC(I)	- 8.6	- 6.4	- 4.5	- 3.0	- 1.7	-0.8	-0.2	.0	-.1	-0.4
COPR	-861	-241	-91	-37	-15	-5	-1	0	0	-1
COPH	-761	-141	8	62	84	94	98	100	99	98

*TH = 40.0 C DT = 0.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0
P	0.4	1.6	3.6	6.4	10.0	14.4	19.6	25.6	32.4	40.1
QH(O)	4.0	8.3	13.1	18.3	23.8	29.8	36.1	42.9	50.1	57.6
QC(I)	3.6	6.7	9.5	11.8	13.8	15.4	16.5	17.3	17.6	17.6
COPR	889	419	263	184	137	106	84	67	54	43
COPH	989	519	363	284	237	206	184	167	154	143

CAMBION® ... THE RIGHT CONNECTION

SUMMARY OF COOLING BY THERMOELECTRICS

TH = 40.0 C DT = 8.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.5	0.9	1.3	1.7	2.1	2.5	2.8	3.2	3.6	4.0
P	0.5	1.8	3.8	6.7	10.3	14.7	19.9	25.9	32.7	40.2
QH(O)	2.4	6.7	11.4	16.6	22.1	28.0	34.3	40.9	48.0	55.5
QC(I)	1.9	5.0	7.6	9.9	11.8	13.3	14.3	15.0	15.4	15.3
COPR	388	281	199	148	114	90	72	58	46	37
COPH	488	381	299	248	214	190	172	158	146	137

TH = 40.0 C DT = 16.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.6	1.0	1.3	1.7	2.1	2.5	2.9	3.3	3.7	4.0
P	0.6	1.9	4.0	6.9	10.6	15.0	20.2	26.2	32.9	40.4
QH(O)	0.8	5.1	9.8	14.9	20.3	26.2	32.4	39.0	46.0	53.4
QC(I)	0.3	3.2	5.8	8.0	9.8	11.2	12.2	12.8	13.1	13.0
COPR	46	167	143	115	92	74	60	49	39	32
COPH	146	267	243	215	192	174	160	149	139	132

TH = 40.0 C DT = 24.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.7	1.0	1.4	1.8	2.2	2.5	2.9	3.3	3.7	4.1
P	0.7	2.1	4.2	7.2	10.8	15.3	20.5	26.4	33.1	40.6
QH(O)	-0.7	3.6	8.2	13.2	18.6	24.4	30.5	37.1	44.0	51.2
QC(I)	- 1.3	1.5	4.0	6.1	7.8	9.1	10.1	10.7	10.9	10.7
COPR	-201	72	93	84	71	59	49	40	32	26
COPH	-101	172	193	184	171	159	149	140	132	126

TH = 40.0 C DT = 32.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.7	1.1	1.5	1.9	2.2	2.6	3.0	3.3	3.7	4.1
P	0.7	2.2	4.5	7.4	11.1	15.6	20.7	26.7	33.3	40.7
QH(O)	- 2.2	2.1	6.6	11.6	16.9	22.6	28.7	35.1	42.0	49.1
QC(I)	- 2.9	-0.2	2.2	4.2	5.8	7.1	8.0	8.5	8.6	8.4
COPR	-391	-7	49	56	52	45	38	31	25	20
COPH	-291	92	149	156	152	145	138	131	125	120

TH = 40.0 C DT = 40.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.8	1.2	1.6	1.9	2.3	2.6	3.0	3.4	3.7	4.1
P	0.8	2.4	4.7	7.7	11.4	15.8	21.0	26.9	33.5	40.9
QH(O)	- 3.7	0.5	5.1	10.0	15.2	20.9	26.9	33.2	39.9	47.0
QC(I)	- 4.5	- 1.9	0.4	2.3	3.9	5.0	5.9	6.3	6.4	6.1
COPR	-541	-77	8	30	33	31	27	23	19	15
COPH	-441	22	108	130	133	131	127	123	119	115

TH = 40.0 C DT = 48.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.9	1.3	1.6	2.0	2.3	2.7	3.0	3.4	3.7	4.1
P	0.9	2.5	4.9	7.9	11.6	16.1	21.3	27.1	33.7	41.0
QH(O)	- 5.1	- 1.0	3.5	8.3	13.6	19.1	25.0	31.3	37.9	44.9
QC(I)	- 6.0	- 3.5	- 1.4	0.5	1.9	3.0	3.8	4.2	4.2	3.9
COPR	-665	-139	-27	5	16	18	17	15	12	9
COPH	-565	-39	72	105	116	118	117	115	112	109

TH = 40.0 C DT = 56.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	1.0	1.3	1.7	2.0	2.4	2.7	3.1	3.4	3.8	4.1
P	1.0	2.7	5.0	8.1	11.9	16.4	21.5	27.4	33.9	41.2
QH(O)	- 6.6	- 2.5	1.9	6.7	11.9	17.3	23.2	29.4	35.9	42.8
QC(I)	- 7.6	- 5.2	- 3.1	- 1.4	-.0	1.0	1.7	2.0	2.0	1.6
COPR	-771	-194	-62	-17	0	6	7	7	5	3
COPH	-671	-94	37	82	99	106	107	107	105	103

TH = 40.0 C DT = 63.3 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	1.1	1.4	1.7	2.1	2.4	2.8	3.1	3.4	3.8	4.1
P	1.1	2.8	5.2	8.3	12.1	16.6	21.7	27.6	34.1	41.3
QH(O)	- 8.0	- 3.9	0.5	5.2	10.3	15.7	21.5	27.6	34.1	40.8
QC(I)	- 9.1	- 6.7	- 4.8	- 3.1	- 1.8	-0.9	-0.3	.0	-.0	-0.5
COPR	-855	-240	-91	-37	-15	-5	-1	0	0	-1
COPH	-755	-140	8	62	84	94	98	100	99	98

*TH = 50.0 C DT = 0.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.4	0.8	1.3	1.7	2.1	2.5	2.9	3.4	3.8	4.2
P	0.4	1.7	3.8	6.7	10.5	15.1	20.6	26.9	34.0	42.0
QH(O)	4.1	8.7	13.7	19.1	24.9	31.1	37.8	44.8	52.3	60.3
QC(I)	3.7	7.0	9.9	12.3	14.4	16.0	17.2	18.0	18.3	18.2
COPR	884	417	261	183	136	105	83	66	53	43
COPH	984	517	361	283	236	205	183	166	153	143

TH = 50.0 C DT = 8.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.5	0.9	1.3	1.7	2.2	2.6	3.0	3.4	3.8	4.2
P	0.5	1.8	4.0	7.0	10.8	15.4	20.9	27.2	34.3	42.2
QH(O)	2.5	7.0	12.0	17.3	23.1	29.3	35.8	42.8	50.3	58.1
QC(I)	2.0	5.2	8.0	10.3	12.3	13.8	15.0	15.7	16.0	15.9
COPR	390	281	199	147	113	89	71	57	46	37
COPH	490	381	299	247	213	189	171	157	146	137

TH = 50.0 C DT = 16.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.6	1.0	1.4	1.8	2.2	2.6	3.0	3.4	3.8	4.2
P	0.6	2.0	4.2	7.2	11.1	15.7	21.2	27.4	34.5	42.4
QH(O)	0.9	5.4	10.3	15.6	21.3	27.4	34.0	40.9	48.2	55.9
QC(I)	0.3	3.4	6.1	8.4	10.2	11.7	12.8	13.4	13.7	13.6
COPR	52	169	144	115	92	74	60	49	39	31
COPH	152	269	244	215	192	174	160	149	139	131

TH = 50.0 C DT = 24.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.7	1.1	1.5	1.9	2.3	2.7	3.1	3.5	3.9	4.3
P	0.7	2.2	4.4	7.5	11.4	16.0	21.5	27.7	34.7	42.5
QH(O)	-0.6	3.8	8.7	13.9	19.6	25.6	32.1	38.9	46.2	53.8
QC(I)	- 1.3	1.7	4.2	6.4	8.2	9.6	10.6	11.2	11.4	11.3
COPR	-193	76	95	85	72	60	49	40	32	26
COPH	-93	176	195	185	172	160	149	140	132	126

TH = 50.0 C DT = 32.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.8	1.2	1.5	1.9	2.3	2.7	3.1	3.5	3.9	4.3
P	0.8	2.3	4.6	7.7	11.6	16.3	21.7	27.9	34.9	42.7
QH(O)	- 2.2	2.3	7.1	12.3	17.9	23.9	30.2	37.0	44.1	51.7
QC(I)	- 2.9	-.1	2.4	4.5	6.2	7.6	8.5	9.0	9.2	9.0
COPR	-380	-2	52	58	53	46	39	32	26	20
COPH	-280	97	152	158	153	146	139	132	126	120

TH = 50.0 C DT = 40.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.9	1.2	1.6	2.0	2.4	2.8	3.1	3.5	3.9	4.3
P	0.9	2.5	4.9	8.0	11.9	16.6	22.0	28.2	35.1	42.9
QH(O)	- 3.7	0.7	5.5	10.6	16.2	22.1	28.4	35.1	42.1	49.6
QC(I)	- 4.5	- 1.7	0.6	2.7	4.3	5.5	6.4	6.9	7.0	6.7
COPR	-528	-70	13	33	35	33	29	24	19	15
COPH	-428	29	113	133	135	133	129	124	119	115

TH = 50.0 C DT = 48.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.9	1.3	1.7	2.1	2.4	2.8	3.2	3.6	3.9	4.3
P	0.9	2.6	5.1	8.2	12.2	16.8	22.3	28.4	35.3	43.0
QH(O)	- 5.1	-0.8	3.9	9.0	14.5	20.3	26.5	33.1	40.1	47.4
QC(I)	- 6.1	- 3.4	- 1.1	0.8	2.3	3.5	4.3	4.7	4.8	4.4
COPR	-649	-130	-22	9	19	20	19	16	13	10
COPH	-549	-30	77	109	119	120	119	116	113	110

TH = 50.0 C DT = 56.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	1.0	1.4	1.8	2.1	2.5	2.9	3.2	3.6	3.9	4.3
P	1.0	2.8	5.3	8.5	12.4	17.1	22.5	28.7	35.5	43.2
QH(O)	- 6.6	- 2.3	2.3	7.4	12.8	18.6	24.7	31.2	38.1	45.3
QC(I)	- 7.7	- 5.1	- 2.9	- 1.1	0.4	1.5	2.2	2.6	2.5	2.2
COPR	-751	-183	-55	-12	3	8	9	8	7	5
COPH	-651	-83	44	87	103	108	109	108	107	105

TH = 50.0 C DT = 64.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	1.1	1.5	1.8	2.2	2.5	2.9	3.3	3.6	4.0	4.3
P	1.1	2.9	5.4	8.7	12.7	17.4	22.8	28.9	35.7	43.3
QH(O)	- 8.1	- 3.9	0.8	5.8	11.1	16.8	22.9	29.3	36.1	43.2
QC(I)	- 9.2	- 6.8	- 4.7	- 2.9	- 1.6	-0.6	.1	0.4	0.3	-.1
COPR	-839	-232	-85	-33	-12	-3	0	1	0	0
COPH	-739	-132	14	66	87	96	100	101	100	99

*TH = 60.0 C DT = 0.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.4	0.9	1.3	1.8	2.2	2.6	3.1	3.5	4.0	4.4
P	0.4	1.8	4.0	7.0	11.0	15.8	21.5	28.1	35.6	44.0
QH(O)	4.3	9.0	14.2	19.8	25.9	32.4	39.3	46.7	54.5	62.8
QC(I)	3.9	7.3	10.3	12.8	14.9	16.6	17.8	18.6	18.9	18.8
COPR	877	413	259	181	135	104	82	65	53	42
COPH	977	513	359	281	235	204	182	165	153	142

SUMMARY OF COOLING BY THERMOELECTRICS

TH = 60.0 C DT = 8.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.5	1.0	1.4	1.8	2.3	2.7	3.1	3.6	4.0	4.4
P	0.5	1.9	4.2	7.3	11.3	16.1	21.8	28.4	35.9	44.2
QH(O)	2.6	7.3	12.5	18.0	24.0	30.5	37.4	44.7	52.4	60.6
QC(I)	2.1	5.4	8.3	10.7	12.8	14.3	15.5	16.2	16.5	16.4
COPR	388	279	197	146	112	88	70	57	46	37
COPH	488	379	297	246	212	188	170	157	146	137

TH = 60.0 C DT = 16.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.6	1.0	1.5	1.9	2.3	2.7	3.2	3.6	4.0	4.4
P	0.6	2.1	4.4	7.6	11.6	16.4	22.1	28.7	36.1	44.4
QH(O)	0.9	5.6	10.7	16.3	22.2	28.6	35.4	42.7	50.3	58.4
QC(I)	0.3	3.5	6.3	8.7	10.7	12.2	13.3	14.0	14.2	14.0
COPR	51	169	144	115	92	74	59	48	39	31
COPH	151	269	244	215	192	174	159	148	139	131

TH = 60.0 C DT = 24.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.7	1.1	1.5	2.0	2.4	2.8	3.2	3.6	4.0	4.5
P	0.7	2.2	4.6	7.8	11.9	16.7	22.4	29.0	36.3	44.5
QH(O)	-0.7	4.0	9.1	14.6	20.5	26.8	33.5	40.7	48.2	56.2
QC(I)	- 1.4	1.8	4.5	6.7	8.6	10.1	11.1	11.7	11.9	11.7
COPR	-193	77	96	86	72	60	49	40	32	26
COPH	-93	177	196	186	172	160	149	140	132	126

TH = 60.0 C DT = 32.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.7	4.1	4.5
P	0.8	2.4	4.8	8.1	12.1	17.0	22.7	29.2	36.6	44.7
QH(O)	- 2.2	2.4	7.4	12.9	18.7	25.0	31.6	38.7	46.2	54.1
QC(I)	- 3.0	-.0	2.6	4.8	6.6	8.0	8.9	9.5	9.6	9.4
COPR	-379	0	53	59	54	46	39	32	26	21
COPH	-279	99	153	159	154	146	139	132	126	121

TH = 60.0 C DT = 40.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	0.9	1.3	1.7	2.1	2.5	2.9	3.3	3.7	4.1	4.5
P	0.9	2.6	5.0	8.3	12.4	17.3	23.0	29.5	36.8	44.9
QH(O)	- 3.7	0.8	5.8	11.2	17.0	23.2	29.8	36.8	44.2	52.0
QC(I)	- 4.6	- 1.7	0.8	2.9	4.6	5.9	6.8	7.3	7.4	7.1
COPR	-525	-67	15	34	36	34	29	24	20	15
COPH	-425	32	115	134	136	134	129	124	120	115

TH = 60.0 C DT = 48.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	1.0	1.4	1.8	2.1	2.5	2.9	3.3	3.7	4.1	4.5
P	1.0	2.7	5.3	8.6	12.7	17.6	23.3	29.7	37.0	45.0
QH(O)	- 5.3	-0.7	4.2	9.6	15.3	21.4	27.9	34.8	42.1	49.8
QC(I)	- 6.2	- 3.4	- 1.0	1.0	2.6	3.8	4.7	5.1	5.2	4.8
COPR	-644	-125	-19	11	20	21	20	17	13	10
COPH	-544	-25	80	111	120	121	120	117	113	110

TH = 60.0 C DT = 56.0 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	1.0	1.4	1.8	2.2	2.6	3.0	3.4	3.7	4.1	4.5
P	1.0	2.9	5.5	8.8	12.9	17.9	23.5	30.0	37.2	45.2
QH(O)	- 6.7	- 2.2	2.7	7.9	13.6	19.7	26.1	32.9	40.1	47.7
QC(I)	- 7.8	- 5.1	- 2.8	-0.9	0.7	1.8	2.6	3.0	3.0	2.6
COPR	-743	-177	-51	-9	5	10	10	9	7	5
COPH	-643	-77	48	90	105	110	110	109	107	105

TH = 60.0 C DT = 66.9 C

I	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
V	1.2	1.5	1.9	2.3	2.7	3.0	3.4	3.8	4.2	4.5
P	1.2	3.1	5.7	9.1	13.3	18.2	23.9	30.3	37.4	45.4
QH(O)	- 8.8	- 4.3	0.5	5.7	11.3	17.3	23.6	30.3	37.4	44.8
QC(I)	- 9.9	- 7.4	- 5.2	- 3.4	- 2.0	-0.9	-0.3	.0	-.1	-0.5
COPR	-855	-240	-90	-37	-14	-5	-1	0	0	-1
COPH	-755	-140	9	62	85	94	98	100	99	98

TEMPERATURE CONVERSION TABLE

−210 to 0			1 to 25			26 to 50			51 to 75			76 to 100			101 to 340			341 to 490		
C.	C. or F.	F.	C.	C. or F.	F.	C.	C. or F.	F.	C.	C. or F.	F.	C.	C. or F.	F.	C.	C. or F.	F.	C.	C. or F.	F.
−134	−210	−346	−17.2	1	33.8	− 3.33	26	78.8	10.6	51	123.8	24.4	76	168.8	43	110	230	177	350	662
−129	−200	−328	−16.7	2	35.6	− 2.78	27	80.6	11.1	52	125.6	25.0	77	170.6	49	120	248	182	360	680
−123	−190	−310	−16.1	3	37.4	− 2.22	28	82.4	11.7	53	127.4	25.6	78	172.4	54	130	266	188	370	698
−118	−180	−292	−15.6	4	39.2	− 1.67	29	84.2	12.2	54	129.2	26.1	79	174.2	60	140	284	193	380	716
−112	−170	−274	−15.0	5	41.0	− 1.11	30	86.0	12.8	55	131.0	26.7	80	176.0	66	150	302	199	390	734
−107	−160	−256	−14.4	6	42.8	− 0.56	31	87.8	13.3	56	132.8	27.2	81	177.8	71	160	320	204	400	752
−101	−150	−238	−13.9	7	44.6	0	32	89.6	13.9	57	134.6	27.8	82	179.6	77	170	338	210	410	770
− 95.6	−140	−220	−13.3	8	46.4	0.56	33	91.4	14.4	58	136.4	28.3	83	181.4	82	180	356	216	420	788
− 90.0	−130	−202	−12.8	9	48.2	1.11	34	93.2	15.0	59	138.2	28.9	84	183.2	88	190	374	221	430	806
− 84.4	−120	−184	−12.2	10	50.0	1.67	35	95.0	15.6	60	140.0	29.4	85	185.0	93	200	392	227	440	824
− 78.9	−110	−166	−11.7	11	51.8	2.22	36	96.8	16.1	61	141.8	30.0	86	186.8	99	210	410	232	450	842
− 73.3	−100	−148	−11.1	12	53.6	2.78	37	98.6	16.7	62	143.6	30.6	87	188.6	100	212	413	238	460	860
− 67.8	− 90	−130	−10.6	13	55.4	3.33	38	100.4	17.2	63	145.4	31.1	88	190.4	104	220	428	243	470	878
− 62.2	− 80	−112	−10.0	14	57.2	3.89	39	102.2	17.8	64	147.2	31.7	89	192.2	110	230	446	249	480	896
− 56.7	− 70	− 94	− 9.44	15	59.0	4.44	40	104.0	18.3	65	149.0	32.2	90	194.0	116	240	464	254	490	914
− 51.1	− 60	− 76	− 8.89	16	60.8	5.00	41	105.8	18.9	66	150.8	32.8	91	195.8	121	250	482			
− 45.6	− 50	− 58	− 8.33	17	62.6	5.56	42	107.6	19.4	67	152.6	33.3	92	197.6	127	260	500			
− 40.0	− 40	− 40	− 7.78	18	64.4	6.11	43	109.4	20.0	68	154.4	33.9	93	199.4	132	270	518			
− 34.4	− 30	− 22	− 7.22	19	66.2	6.67	44	111.2	20.6	69	156.2	34.4	94	201.2	138	280	536			
− 28.9	− 20	− 4	− 6.67	20	68.0	7.22	45	113.0	21.1	70	158.0	35.0	95	203.0	143	290	554			
− 23.3	− 10	14	− 6.11	21	69.8	7.78	46	114.8	21.7	71	159.8	35.6	96	204.8	149	300	572			
− 17.8	0	32	− 5.56	22	71.6	8.33	47	116.6	22.2	72	161.6	36.1	97	206.6	154	310	590			
			− 5.00	23	73.4	8.89	48	118.4	22.8	73	163.4	36.7	98	208.4	160	320	608			
			− 4.44	24	75.2	9.44	49	120.2	23.3	74	165.2	37.2	99	210.2	166	330	626			
			− 3.89	25	77.0	10.0	50	122.0	23.9	75	167.0	37.8	100	212.0	171	340	644			

NOTE:—The numbers in bold face type refer to the temperature either in degrees Centigrade or Fahrenheit which it is desired to convert into the other scale. If converting from Fahrenheit degrees to Centigrade degrees the equivalent temperature will be found in the left column, while if converting from degrees Centigrade to degrees Fahrenheit, the answer will be found in the column on the right.

$$°F = \frac{9}{5}(°C) + 32$$

$$°C = \frac{5}{9}(°F - 32)$$

INTERPOLATION FACTORS

C.		F.	C.		F.
0.56	1	1.8	3.33	6	10.8
1.11	2	3.6	3.89	7	12.6
1.67	3	5.4	4.44	8	14.4
2.22	4	7.2	5.00	9	16.2
2.78	5	9.0	5.56	10	18.0

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MILLIMETERS TO INCHES

Mm.	In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	In.
1	0.039370	26	1.023622	51	2.007874	76	2.992126	25,4	1
2	0.078740	27	1.062992	52	2.047244	77	3.031496	50,8	2
3	0.118110	28	1.102362	53	2.086614	78	3.070866	76,2	3
4	0.157480	29	1.141732	54	2.125984	79	3.110236	101,6	4
5	0.196850	30	1.181102	55	2.165354	80	3.149606	127,0	5
6	0.236220	31	1.220472	56	2.204724	81	3.188976	152,4	6
7	0.275591	32	1.259843	57	2.244094	82	3.228346	177,8	7
8	0.314961	33	1.299213	58	2.283465	83	3.267717	203,2	8
9	0.354331	34	1.338583	59	2.322835	84	3.307087	228,6	9
10	0.393701	35	1.377953	60	2.362205	85	3.346457	254,0	10
11	0.433071	36	1.417323	61	2.401575	86	3.385827	279,4	11
12	0.472441	37	1.456693	62	2.440945	87	3.425197	304,8	12
13	0.511811	38	1.496063	63	2.480315	88	3.464567	330,2	13
14	0.551181	39	1.535433	64	2.519685	89	3.503937	355,6	14
15	0.590551	40	1.574803	65	2.559055	90	3.543307	381,0	15
16	0.629921	41	1.614173	66	2.598425	91	3.582677	406,4	16
17	0.669291	42	1.653543	67	2.637795	92	3.622047	431,8	17
18	0.708661	43	1.692913	68	2.677165	93	3.661417	457,2	18
19	0.748031	44	1.732283	69	2.716535	94	3.700787	482,6	19
20	0.787402	45	1.771654	70	2.755906	95	3.740157	508,0	20
21	0.826772	46	1.811024	71	2.795276	96	3.779528	533,4	21
22	0.866142	47	1.850394	72	2.834646	97	3.818898	558,8	22
23	0.905512	48	1.889764	73	2.874016	98	3.858268	584,2	23
24	0.944882	49	1.929134	74	2.913386	99	3.897638	609,6	24
25	0.984252	50	1.968504	75	2.952756	100	3.937008	635.0	25

The above table is approximate on the basis: 1 in. = 25.4 mm. 1/25.4 = 0.039370078740 +

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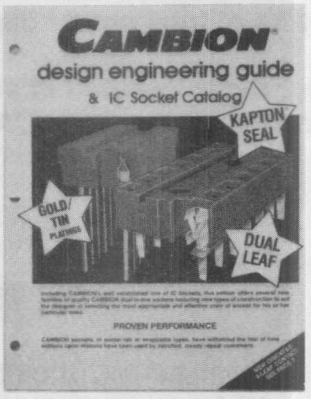

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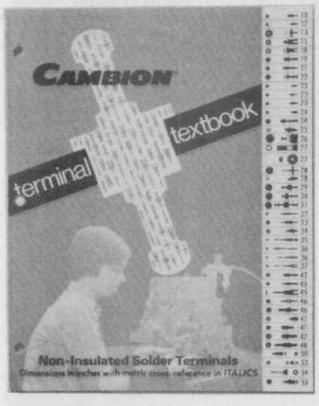

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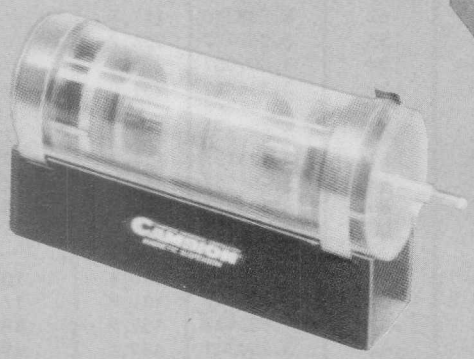
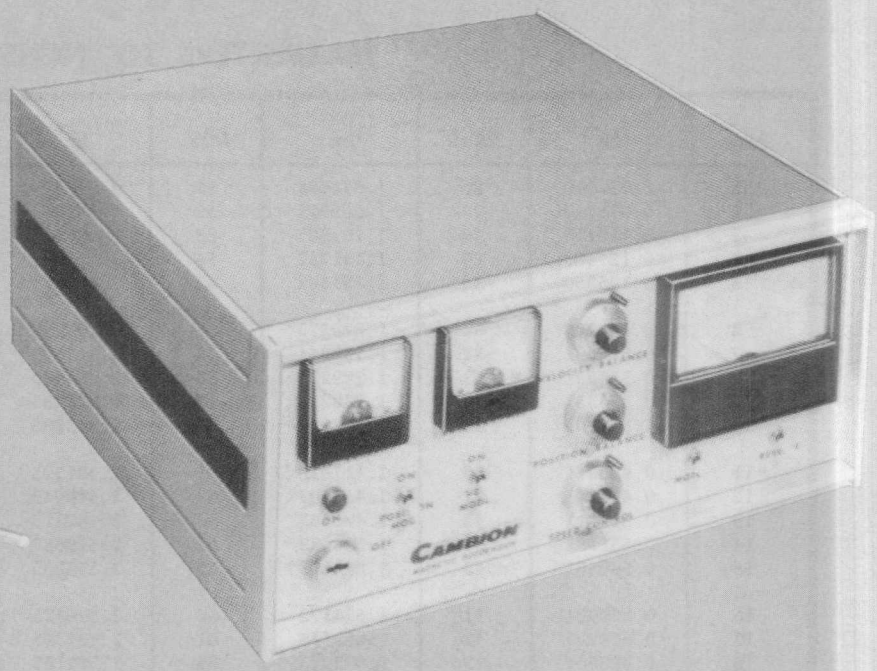
MAGNETIC BEARING SYSTEMS





Magnetic Bearings, researched by CAMBION since 1963, are now combined with two types of motors: Hysteresis motors for exact speed control and Brushless DC permanent magnet motors for higher torque operation.

Magnetic Bearing Systems are ideal for high-vacuum, high-speed operations. They are also preferred for applications requiring low noise, low vibration and non-contaminated environments.

CAMBION's patented Virtually Zero Power (VZP) technique makes all that possible with only a few watts of total power capable of suspending any significant weight ranging from 50 grams to 1 ton.

Our technical staff is available to assist you with your suspension applications. Write for our VZP-1A brochure or call the CAMBION Magnetic Bearing Department at (617) 491-5400, extension 57.

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In the interest of improved design and performance, Cambridge Thermionic Corporation reserves the right to make changes in its specifications without prior notice.

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